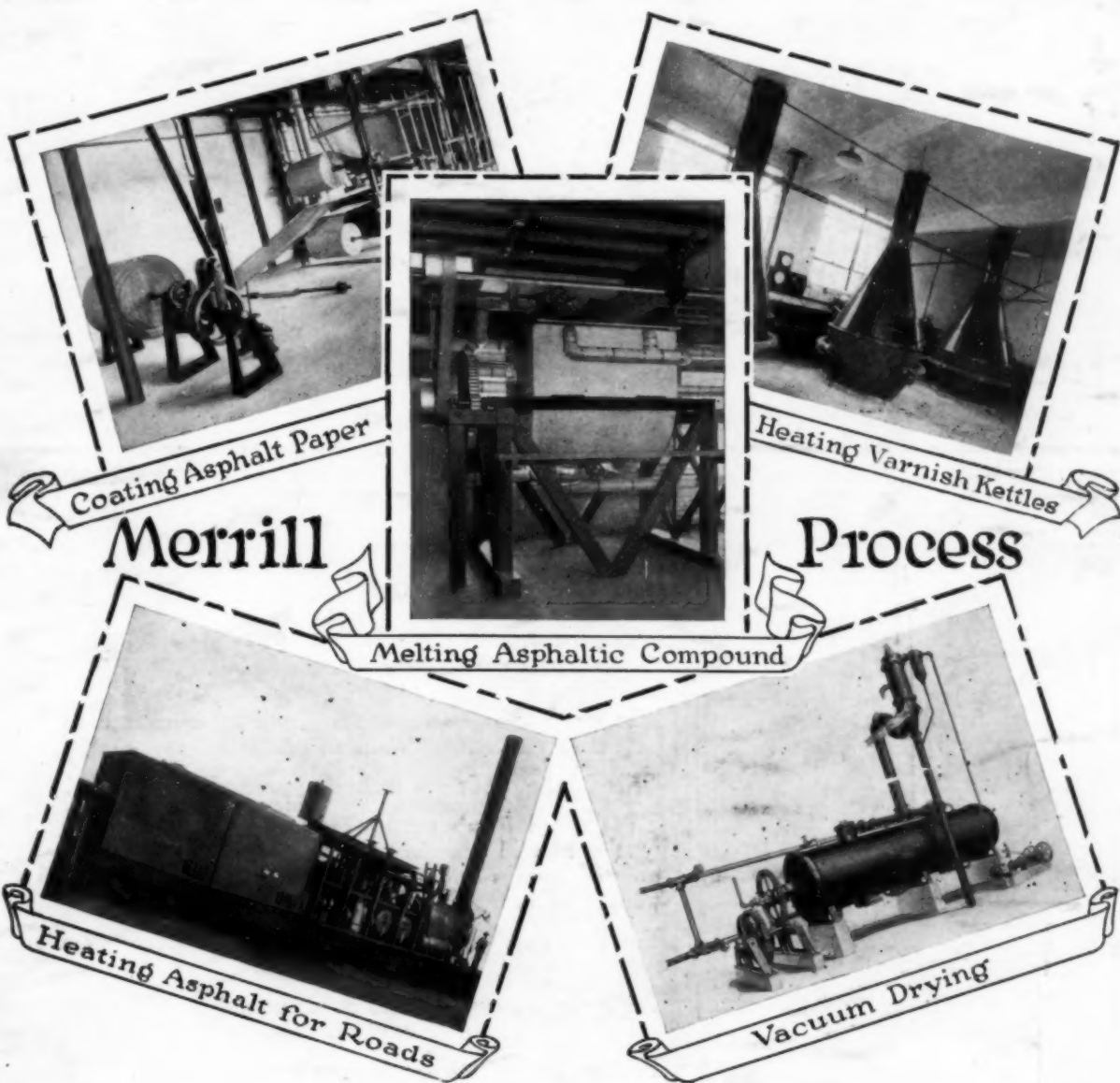


CHEMICAL & METALLURGICAL ENGINEERING

McGraw-Hill Co., Inc.

January 11, 1922

25 Cents Per Copy



The field for **OIL HEATING** is increasing
You may find an application to YOUR problem in some of our literature
Drop us a line and we'll put you on the mailing list

Parks-Cramer Company

*Engineers & Contractors
Industrial Piping and Air Conditioning*

1102 Old South Building, Boston, Mass.



Shriver Efficiency

Many years of producing filter presses for all types of filtration work enable us to guarantee the results.

This guarantee of efficiency goes with every filter press we sell—we know our product, and we are ready to stand back of it. Write for catalog stating your filtration problem.

T. SHRIVER & CO.

808 Hamilton Street, Harrison, N. J.

Smoke Is a Nuisance

Get rid of smoke by burning Pulverized Coal

Cut operating costs at the same time by burning a cheap grade of fuel efficiently. The Quigley Fuel Systems prepares, transports and burns powdered coal with remarkable ease and low cost.

HARDINGE COMPANY

120 Broadway, New York

Quigley Pulverized Fuel Systems



Parr Calorimeters

For determining the calorific value of fuels

The peroxide bomb outfit has electric ignition and is very extensively used for obtaining the B.T.U.s of coal.

Price of the outfit not including motor is . . . \$100.00

The oxygen bomb outfit (see cut) has the bomb made wholly of acid resisting alloy (illium). Thus platinum or gold linings with their many disadvantages are dispensed with.

The Parr oxygen bomb outfit is especially recommended for determining the B.T.U.s of oils.

Price of the oxygen bomb outfit complete, not including motor or oxygen, \$300.00

Price of Parr adiabatic oxygen bomb outfit, . . . 400.00

EIMER & AMEND

Established 1851

New York, N. Y.
200 East 19th Street

Pittsburgh Office
4048 Jenkins Arcade
Washington, D. C.
Suite 601, Evening Star Bldg.

CHEMICAL & METALLURGICAL ENGINEERING

H. C. PARMELEE
Editor
ELLWOOD HENDRICK
Consulting Editor
ERNEST B. THUM
Associate Editor
SIDNEY D. KIRKPATRICK
ALAN G. WIKOFF
Assistant Editors

R. S. McBRIDE
CHARLES N. HULBERT
A. E. BUCHANAN, JR.
Assistant Editors
CHESTER H. JONES
Industrial Editor
J. S. NEIGHT
Managing Editor

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY and IRON & STEEL MAGAZINE

Volume 26

New York, January 11, 1922

Number 2

"Prohibiting" Chemical Warfare

THE accomplishments of the Disarmament Conference have been of an epoch-making character and the high principles that have guided its work have received universal acceptance and approval. It is, therefore, with no small measure of temerity that we raise our voice to question its recent stand on chemical warfare. As an expression of humane purpose and magnanimous intent the resolution may be worth while, but as a means of actually prohibiting the use of gas in warfare we are inclined to doubt its efficacy. Some way or other we cannot help but feel that it was a mistake to disregard the recommendations of the committee of experts and to accept the views of the non-technical advisers, even though they included officers high in the councils of the Army and Navy Departments.

It will be recalled that the committee of experts consisted of Professor EDGAR F. SMITH, chairman, and Brigadier-General AMOS A. FRIES for the United States, Colonel BARTHOLOMEW for Great Britain, Professors MOUREU and MAYER for France, Colonel PENTINALLI for Italy, and Major-General HARAGUCHI for Japan. This committee had presented a logical, convincing report supported by incontrovertible evidence from the late war. They proved that it was not feasible for the Conference to attempt to prohibit gas warfare, and that manufacture of poison gas as a military agency could not be controlled. On the other hand, the reports of those who opposed this form of warfare were noticeably weak, in our opinion, and inclined to deal in the sort of generalities that appeal to our broader sympathies, even though they do not always influence our better judgment. They state that chemical warfare is "a cruel, unfair and improper use of science," but for that matter so is all of warfare. Furthermore, it is quite contrary to the fact to claim that the use of gas inevitably results in its application to non-combatant as well as combatant. An unscrupulous enemy might so apply it, but there is no more reason why he must than there is that he should bomb a defenseless city with high explosive or sink an unprotected hospital ship with his torpedoes. The choice is his.

But let us turn to the resolution for a minute to find out, if we can, something of its real significance. It reads as follows:

The use in war of asphyxiating, poisonous or other gases and all analogous liquids, materials or devices having been justly condemned by the general opinion of the civilized world and a prohibition of such use having been declared in treaties to which a majority of the civilized powers are parties;

Now to the end that this prohibition shall be universally accepted as a part of international law binding alike the conscience and practice of nations, the signatory powers declare their assent to such prohibition, agree to be bound thereby between themselves and invite all other civilized nations to adhere thereto.

Is chemical warfare to be forgotten as a nightmare

of the past or does this resolution mean, as one diplomat is quoted as saying, "that in the next war each of us promises to wait until the other fellow uses gas before we do?" The mere restating of an international law which has already failed to withstand the actual test of war can scarcely be regarded as a lasting solution of this problem. Under these circumstances preparation for chemical warfare must go on, for no nation can afford to be unprepared against a treacherous nation which may refuse to be governed by the law of nations. There are no penalties attached as was the case with the submarines, which, by the way, were limited as to use and not abolished. The only punishment awaiting the user of poison gases is the moral condemnation of other nations, and this, to be effective, depends upon the support given it by the public opinion of the world.

The attitude of the other powers toward the Conference resolution is a matter of considerable interest. Great Britain appeared somewhat skeptical of its efficacy. The French delegates seemed considerably more enthusiastic in according their approval to the resolution, while in the case of the Italians and Japanese the proposition was met with joyous acclaim. Apparently the sentiment against chemical warfare varies inversely with the size and development of a nation's organic chemical industry.

The importance of peace-time chemical plants for dyes and medicines is still evident. Governments bound by international agreement to prohibit gas warfare will continue to make gas masks and other defensive equipment, but they cannot, in good faith, erect and operate chemical arsenals for the production of poison gases. Should the world again be faced by a conscienceless enemy, the only safe preparedness lies in the organic chemical industry, with its plants and chemically trained personnel.

All Is Vanity

And Vexation of Spirit

BY WHAT curious twist of the ego does a man who has achieved reputation and eminence in his chosen calling betray himself into attempting to speak with authority on other matters of which he knows little or nothing? What is it that apparently leads a man to believe that because his opinion would be accepted on a certain subject, his voice will be equally effective if lifted up in the wilderness of his ignorance? Recently we seem to have had an epidemic of this kind of public pronouncement by prominent men on topics quite outside their knowledge.

First, Mr. EDISON and Mr. FORD inspected the great nitrate plant at Muscle Shoals and we were informed that the former was so pleased with the place that "he would like to wander through it all night." We admit it is a fascinating plant, and we are only sorry that the process used at No. 1 was a failure. But Mr.

EDISON was more than fascinated, and we can take heart because he "offered several suggestions for making the process a success, but as the plant is not running they cannot be tried out now." This is truly unfortunate. Mr. EDISON should have visited the plant several years ago.

And after Mr. FORD had been to Muscle Shoals he delivered himself of a profound opinion on money and methods of financing which consist simply in "displacing gold as the basis of currency and substitute in its place the world's imperishable natural wealth." Thus we would put an end to war because "the cause of all wars is gold." He would substitute energy units for the precious metal and issue currency thereon—a sort of horsepower dollar.

But at the same time that Mr. FORD was condemning gold, Professor IRVING FISHER, economist of Yale University, was upsetting all our industrial calculations by holding out the possibility of Germany paying her reparations by means of synthetic gold. Addressing the London School of Economics, Professor FISHER is reported as saying that he has "been credibly informed that a German chemist has already succeeded in a laboratory in making synthetic gold out of baser metals by means of an electric vacuum furnace." Note the vacuum. Let the process become cheap enough and the Germans could "flood the world with chemically manufactured gold and so make it worthless." This should satisfy Mr. FORD.

We repeat the question with which we opened our discourse, and leave the reader to answer. When Mr. EDISON talks on electricity, Mr. FORD on automotive industry and Professor FISHER on economics we listen with rapt attention, but somehow when they respectively deliver sober opinions on nitrogen fixation, economics and synthetic gold, we grow restless and perhaps a bit disrespectful. We wish they wouldn't do it, because we like to hold them in the highest esteem.

Salaries for

Government Professional Men

ON DECEMBER 15 the House of Representatives passed a bill (H.R. 8,928) for the classification of civilian positions in the government which establishes grades for the professional workers in the federal service. In order that uniformity of practice may prevail in the several technical bureaus and proper attention be given to salary scales of all, it is a distinct step forward to have this bill receive favorable action.

The salaries provided for beginners (college graduates) in professional work will be from \$1,620 to \$1,980. The next grade will be \$2,100 to \$2,640, and so on until finally the highest compensation recognized is for those in the chief professional grade, which "shall include all classes of positions in this service the duties of which are to act as the technical and administrative head of a major professional or scientific bureau," for which the compensation is to be \$5,400 to \$6,600 unless a higher rate is specifically authorized by law. No one will claim that these salaries are wholly adequate, especially in the higher grades. But apparently they represent a slight increase for the professional workers and as such should be welcomed.

The legislation is, however, seriously defective in two particulars. It provides that all vacant or new positions must be filled at the minimum rate of the appropriate grade. Thus apparently if a man is not qualified for \$2,100 as an assistant chemist, the maxi-

mum which could be paid him would be \$1,620. In other words an \$1,800 man outside the service could not be recognized as such even though an \$1,800 vacancy might exist; such vacancy would have to be filled by promotion. Also it would appear that the bill contemplates more or less automatic promotion for professional workers "not more than once a year." This places the professional workers as cogs in a mechanical personnel scheme of the most vicious sort. It applies the rule of seniority almost without regard to merit or efficiency.

Industries interested in chemical classification and compensation of professional workers will be glad to study and may profit by considering the proposed rates of compensation and the rather loose but significant classification of the positions. However, it is certainly to be hoped that they will not follow either a rigid scheme of salary fixing or any idea of automatic promotions. Either of such practices is vicious in the extreme when applied to scientific or professional workers.

Co-operation to Promote

Our Foreign Trade in Chemicals

THE Bureau of Foreign and Domestic Commerce has made an unquestioned success of its effort in the commodity divisions already organized for the furtherance of foreign trade by investigation and report on domestic and foreign problems of production, distribution and marketing. One of the very first divisions contemplated last year, when this work was being planned by Secretary HOOVER and his assistants, was a division of chemicals. However, that division of the work has never been organized, largely if not wholly because the industries for which the service was designed showed a very obvious unwillingness to co-operate in the work. Apparently the difficulty arose from a confused idea in the minds of some prominent members of the heavy-chemicals industries that this work in promotion of export was interlocked with some statistical work regarding the domestic industries in the Bureau of the Census to which these industrial leaders found objection.

For the fiscal year beginning July 1, 1922, it is proposed in the national budget that additional commodity divisions be organized. Thus far there have been more than a dozen such divisions, including those on iron and steel, rubber goods, textiles, fuels, leather, etc. It is now proposed that divisions be added to deal with vegetable oils and breadstuffs, dyes and drugs, heavy chemicals, paints, varnishes and tanning materials, paper, non-ferrous metals, glass and earthenware, petroleum and others not so directly of chemical interest. And the need for these is clear.

Stabilization of many chemically controlled industries demands that at least a small percentage of the products of these industries be exported. The federal government's effort to stimulate and stabilize such export business is, therefore, of great importance. It is to be hoped that the requested appropriations for the extension of the work will be granted.

It is even more to be hoped that the chemical industries will not again make the mistake of seeming to be unwilling to co-operate with the Department of Commerce. That department can do much good for the industries, and if co-operation on the proper basis is assured there is no likelihood of objectionable practice within the department. The organic chemical industries of the country recognize these facts. May the other branches of chemical business appreciate them also.

Soft Lead And Soft Soap

A SERIES of four articles by JEROME ALEXANDER, discussing the colloid state in metals and alloys, commences in this issue. It is of a nature which should and probably will interest many readers, both metallurgists and chemists, as the title attempts to indicate. Again, its perusal should build an excellent background for Dr. BANCROFT's forthcoming lecture before the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers on "Colloid Chemistry and Metallurgy," even though it may be expected that these two gentlemen will view the subject in different perspective. Rather than infer the ultimate constitution of alloys from information gained when studying viscous colloids, BANCROFT would probably reverse the process, and argue from the "simple" alloy structure to the "complex" jelly.

The principles of colloid chemistry undoubtedly have intimate bearing upon that most practical problem of metallurgy: hardening. It has long been accepted that at high temperatures, carbon (the iron-hardener) is in solution or atomic dispersion in the hot solid metal, whereas after slow cooling it accumulates into visible crystals of carbide. Somewhere early in the range between these two extremes, which are both soft, occurs a certain arrangement of submicroscopic (and doubtless colloidal) particles of carbide which is associated with extreme hardness. Such facts as these led ALEXANDER, as early as 1908, to assume that maximum hardness in metal corresponds to "zones of maximum colloidal," where the system exhibits surface phenomena to the highest extent.

At that time steel was about the only metal which could be usefully hardened. In more recent years duralumin has been shown to be another such, and Dr. MERICA led fellow investigators in defining the conditions of its behavior, thus: "There is a certain size of particle of CuAl , [insoluble in the aluminum] for which the hardness of the material is a maximum." Dr. JEFFRIES later dubbed this condition a "critical dispersion." Recently he has given a highly useful view on the actual mechanism of hardening action in his paper on "Slip Interference Theory of the Hardening of Metals," appearing in these columns a few months ago—a contribution, by the way, which many chemists could read with advantage, despite its metalliferous title.

It may only be invidious to discuss priority in these ideas, and doubtless agreement could never be reached among colloid chemists and physical metallurgists, because of a fundamental difference in mental processes. The chemist fixes his attention upon surface forces, and without requiring any working model of their action, readily agrees with ALEXANDER that there is a certain fine subdivision of phases which possesses the maximum amount of internal energy and hence greatest hardness. The metallurgist requires a more, shall we say, mechanistic demonstration of the problem. He has been used to working with solid and relatively rigid masses of crystalline metal; he associates the idea of hardness with certain tests he has made on the metal; he observes certain microscopic changes to accompany permanent deformation; and naturally an explanation of hardness which appeals to him must use his terms and explain his facts. This Dr. JEFFRIES and Mr. ARCHER have done in a most skillful way.

Perhaps both are right!

Byproduct Coking For the Public

IN ONE SENSE we have been doing exactly the wrong thing with byproduct coke ovens, for most of those we have built have been located adjacent to blast furnaces. Of course the word "we" is used to represent society collectively. It may be asked how a better location for a plant can be found than next door to the largest consumer of the product involved. It is true the blast furnaces have been using 75 or 80 per cent of all the coke the country has been producing, but the coke produced represents only about 10 per cent of all the bituminous coal produced. Speaking for national economy, a great many of those who are consuming bituminous coal should be using byproduct coke.

Most of the byproduct ovens built have been located at blast furnaces because the steel industry had the capital and was willing to invest it. The record of 1921, with production of both pig iron and steel ingots at 37 or 38 per cent of the productive capacity, shows that the blast furnace is not a steady consumer of coke. Households and public utilities are much steadier consumers, and as a byproduct coking plant is one that involves a very heavy investment, it should be predicated on as steady an operation as can be compassed.

The wide variation in blast-furnace coke requirements from time to time has occasioned much less economic loss than would be the case if byproduct ovens were depended on solely at the time of maximum load. Speaking approximately, the coking capacity of the country is divided one-half beehive and one-half byproduct. Last July, when blast-furnace operations were at their minimum, coke production was aligned one-eighth beehive and seven-eighths byproduct, and thus in a measure the remaining beehive coke ovens of the country exist to carry the peak of the load.

It might be argued that the blast furnace and steel plant can provide itself with a full complement of byproduct coke ovens, and then sell to the public when its own requirements are light, as is so frequently the case. One difficulty is that rail freight rates are high even for very short coke hauls, while a greater difficulty is that the gas cannot be freighted at all. The byproduct coking plant located near a municipality can truck its coke and pipe its gas and count on a much steadier demand than is furnished by blast furnaces and steel mills.

It is established that the iron and steel industry can well afford to carry byproduct coke-oven investment even though the employment of the facilities is quite irregular. Much more, then, can the investment be carried when the arrangement is such that there is a relatively steady demand for the coke and gas. A recent transaction involving approximately 100,000 tons of byproduct coke indicated that the producer had a leeway of about a dollar a ton in underselling the actual cost of producing and transporting Connellsville coke. The computation was complicated, involving cost of coal and coal freights, value of byproducts, etc., but the net result was approximately as stated. The byproduct coke producer does not, however, retain the money, since nearly all of it goes to the railroad that transports the coke. If the ovens could be moved to the point of coke consumption for the life of the contract, this would be saved, as the assembly cost of the coal would not be increased. Thus it is advantageous to locate the plant so that there will be no freight on the coke. There is no milling-in-transit arrangement for coal and coke.

Readers' Views and Comments

Seriums and Anta Toxines

To the Editor of Chemical & Metallurgical Engineering

SIR:—My friend —, well, now, never mind what his name is. He is a little shy about seeing it in print, but I shall ask you to take it from me that he is a real chemist and would be one even in New Jersey, where they are tagging them. He has been receiving letters in reference to a chemical venture in Kansas City from the treasurer of the prospective concern, and on reading them they seemed so interesting to me that I begged him to let me offer at least one of them to you for publication. This reads:

Dear Sir, I am writing you at the suggestion of Mr. — of —. He tells me you are a practical Chemist, now at this time we are Organizing a large plant for Kans City Mo. we have enough Stock sold and promised at the present time to put it over in a smaller way than we wanted to start with; but we are not tiard of well doing so are going to add some more to what we now have, we expect to Manufacture a full and compleet line of Chemicals and specilize in Seriums Anta Toxines, Glanular Extracts, and in fact other lines not mentioned, we thought perhaps you would like to connect yourself with a concern like this, in a Financial way at the present time, and in the future you wished to employ yourself in this capacity in this part of the U S, the writer believes it would be a fine thing for you to associate yourself with this young Factory before the present issue of stock is raised in price above par we are issueing Stock at par value of \$10.00 per share would like to hear from you if interested will mail you a compleet prospectus of the whole situation. Respt Yours
J. D. HENDERSON, Treas.

There is another one from the same erudite gentleman setting forth the advantage of getting in on the ground floor so that my friend may participate in "the groth" of the company. It tells him that, he being a chemist, "there is no use to dwell on the profeit end of the business" and "hense" he will understand it.

The officers of the company are respectively Messrs. Thompson, president; Henson, secretary, and Henderson, treasurer—all sons, you observe. The correspondence makes me want to urge old Mr. Thomp, Mr. Hen and Mr. Hender to send the boys to school for a while before they begin to produce their "seriums."

There is nothing to hinder these promising gentlemen from engaging in pharmaceutical industry, but I can't help wondering how the scholarly gentlemen of the Kansas City Section of the A.C.S. will greet their new colleagues.
MARTIN SEYT.

Various Methods for Hardening High-Speed Steel

To the Editor of Chemical & Metallurgical Engineering

SIR:—I have read with interest Mr. d'Arcambal's paper on "Various Methods for Hardening High-Speed Steel," which is published in the Dec. 21, 1921, issue of CHEMICAL & METALLURGICAL ENGINEERING. Mr. d'Arcambal, in speaking of blisters and pitting of high-grade steel when heated in barium chloride, lays this trouble to the graphite crucible.

Several years ago I had occasion to experiment with barium chloride as a heating bath for high-speed steel. The furnace first used was an oil-fired crucible furnace, the container was a graphite crucible. The work hard-

ened from this bath when new, showed no sign of blister or pitting, but after a day or so of use the steel would blister. In form the appearance of these blisters was that of oyster shells. Examination at that time led us to believe that the trouble came about by the surface of the steel flowing from one spot and building up at another spot. In other words, pits and blisters existed together. It was found that this trouble could be eliminated by a renewal of the barium chloride until that in turn became unfit for use. It was also found that an accumulation of molten metal took place at the bottom of the crucible. This was found accidentally by dropping the tool being hardened to the bottom and on its removal a considerable quantity of this metal had adhered to it, rendering it quite useless. At first it was thought the tongs and poker used in holding the work had melted sufficiently to cause this accumulation. Some of this metal was saved and although never analyzed, it was undoubtedly due mainly to successive drippings from the high-speed tool.

Brearely, in his "Heat-Treatment of Tool Steel," shows several pictures relating to the above findings. He also analyzed the metal found at the bottom of the crucible as follows: Carbon 2.56 per cent, manganese nil, chromium 1.13, tungsten 8.48.

It is a question whether this action of barium chloride on steel is in any way related to the action of borax in carburizing and adding of new metal, as claimed under British patent 125,666, by Samuel Whyte, May 1, 1919.

Hardening of high-speed steel in barium chloride contained in a firebrick crucible did not cause the trouble referred to in the graphite crucible.

Hartford, Conn.

S. P. ROCKWELL.

Hydrochloric Acid as an Etching Reagent

To the Editor of Chemical & Metallurgical Engineering

SIR:—In your journal of Nov. 23 we noted an article on the use of concentrated hydrochloric acid as an etching reagent for nickel, written by Henry S. Rawdon and Marjorie C. Lorentz. This proved doubly interesting to us, as we had accidentally discovered the value of hydrochloric acid in this connection.

A short time ago, while using nickel shot as a reducing agent in a rough analysis of a solution of tin in concentrated hydrochloric acid, we noted that very shortly after boiling commenced, the nickel appeared to be etched. Subsequently, a specimen of the same nickel was properly prepared and polished, and the etching value of boiling concentrated hydrochloric acid tried. The results were highly satisfactory. In from 2 to 5 minutes etching was completed, the crystal being as clearly defined and contrasted as those shown in Fig. 1b, of the above article, which represents a section of a sample which had had 1 hour's etching with cold concentrated acid.

We have since on different occasions used boiling concentrated hydrochloric as a metallographic etching reagent for nickel, and uniformly excellent results have been obtained.

Faculty of Applied Science,
University of Toronto.

W. G. ROBERTSON,
A. H. MELLISH.

British Chemical Industries

FROM OUR LONDON CORRESPONDENT

LONDON, Dec. 17, 1921.

PROBABLY the chief topics for discussion during the past month have been the santonine and gas mantle cases, which have just been dealt with by Cyril Atkinson, K.C., the referee appointed under the safeguarding of industries act. While British chemical industry as a whole has been deeply concerned as to the outcome of these test cases and the technical journals have given considerable prominence to the very conflicting evidence presented by the "experts," the daily press, including the *Times*, has scarcely referred to what are certainly far-reaching decisions of great importance to industry.

WHEN IS A CHEMICAL NOT A CHEMICAL?

In some respect the chemical evidence and the judicial mind may be said to have been trying to answer conundrums rather than taking a broad common sense view. Santonine is a medicinal chemical extracted from flowers grown in south Russia, and its supply is at present under the control of German and Russian interests, which have raised the price by about 800 per cent over the pre-war level. The raw material could also be collected within the British Empire and santonine is apparently a crystalline substance of definite composition, which might conceivably be synthesized and thus ultimately come under the act as a synthetic organic chemical. Yet on the balance of the evidence it has been held that it is not a "fine" chemical, and so the game goes on. The primary purpose of the act is to safeguard industries actually carried on or likely to be carried on in this country, and in excluding santonine from its operation the general opinion seems to be that the decision interprets the spirit of the act and the intentions of the legislature. Next week it is the turn of calcium carbide on the motion of the British Cellulose & Chemical Manufacturing Co., of airplane dope fame, which installed at the request of the government a 30,000-ton carbide plant during the war, and although this manufacture may not be economically sound, it is thought to be a key industry requiring protection. If, on the evidence, carbide is deemed to be an organic chemical, an import duty of 33 per cent would be imposed, and speculation is rife as to what would then happen in the case of putative organic compounds such as the carbonates, carbon bisulphide, solid carbon dioxide, dissolved acetylene and kindred substances containing carbon. The third case to be heard will be that of cream of tartar, and it is confidently predicted that by then our legal luminaries will be in hospital suffering from brain fever.

RARE EARTHS IN GAS MANTLES TO PAY DUTY

The gas mantle case turned on the conundrum, "When is a compound not a compound?" some of the experts suggesting that a chemical compound was necessarily referred to in the act and that a mixture was not included. The common sense view prevailed in this case and the cerium and thorium contents of the mantle are now subject to duty, but not the gas mantle as a whole. Probably further protection under the dumping clauses will now be sought by the manufacturers, as unless the whole mantle is taxed, the amount of the duty imposed would be insufficient to enable continental competition to be met successfully. Both in the santonine and gas mantle cases the awards have not

yet been signed and the Board of Trade appears to be unjustifiably endeavoring to have the decisions modified—probably without success.

SIR ARTHUR DUCKHAM ANNOUNCES PROBABLE SOLUTION OF PEAT-DRYING PROBLEM

In stating last month that one or two important inventions were on the point of fruition, the new drier and evaporators for the treatment of peat developed by Peco, Ltd., which has carried on the work of Wet Carbonising, Ltd., and Testrup, were among others in your correspondent's mind. It is understood that 1 ton of fuel in these apparatus will be capable of removing about 20 tons of moisture from peat, and an experimental plant is now being erected with a capacity of about 40 tons a day. Sir Arthur Duckham is at the head of Peco, Ltd., and is very sanguine as to the future of the invention, which should be of great importance to Canada, Italy and Great Britain among others. Plauson's colloid mill, regarding which propaganda has recently been made, is perhaps in a different category, because it has been very difficult to obtain trustworthy information or to get down to business. Briefly, Plauson claims to grind in water as a disperse medium rubber and many other materials to a fineness of between $1\ \mu$ and $10\ \mu$ —i.e., 0.001 mm. and 0.00001 mm.—and that in this "colloidal" condition with or without the addition of certain substances acting as protective colloids an entirely new field is opened in soap manufacture, fat hardening, colloidal wood, graphite, etc. Plauson and his financial agent in London have protected the invention with a cloud of patents, but so far no one seems to have seen the mill in satisfactory operation or has learned anything regarding its efficiency, output or the power required to drive it.

GENERAL NOTES

There is quite a vogue in rustless irons and steels at the moment and in addition to Vickers' and Krupp's steels referred to in my last month's notes, the rustless iron made by J. J. Saville & Co., Ltd., is worthy of notice. It differs from the others in not requiring hardening and in that it is ductile with a tensile strength of 40 tons and an elongation of 25 per cent with a reduction of area of 60 per cent. These properties enable it to be pressed, spun, stamped or cold-worked into the most intricate shapes without requiring subsequent heat-treatment, and in the soft condition, when polished, will not tarnish or rust and will probably also find a limited application in the chemical industry. Very little progress has been made in electrolytic iron and the new material seems to be a good substitute. West's paper on the Claude process [see p. 58 of this issue] has failed to draw any reply or information from the Brunner Mond group and meanwhile there is a tendency to reconsider the merits of the Häusser explosion process for direct production of nitric acid from coke-oven gas, which would be a very useful adjunct to ammonia synthesis, particularly as the oxygen obtained as a byproduct could be used to increase the yield from the explosion process. The recent cinematograph evening organized by the Society of Chemical Industry was the first of its kind in this country and it is generally thought that the use of motion pictures so prevalent in America will be extended and that films shown in the future will be of a standard more comparable with those usual in America.

Colloidal State in Metals and Alloys. I—Molten Metal

Just Prior to Solidification, Metal and Glass Show Many Similarities—Pure Molten Metals Are Doubtless Isocolloids—Ultramicroscopic Researches on Glass Are Quoted to Indicate Expected Results When Such Studies May Be Extended to Metal

By JEROME ALEXANDER*

THE object of this paper¹ is to show that many of the important phenomena of metals and alloys are due to the facts that at a certain stage of their existence they or some of their constituents are in a colloidal state of subdivision, and that notwithstanding the generally brief duration of this stage and the powerful crystallization tendency of metals, a portion of the metal or alloy tends to remain in the colloidal state and exert a powerful influence upon the physical properties of the final solid magma. Incidentally it will become evident that the so-called amorphous phase in pure metals is an isocolloid, consisting of colloidal groups of metal molecules which may be dispersed in still more finely subdivided metal; that these colloidal particles are not truly amorphous, but may consist in part, if not entirely, of ultramicroscopic crystals; and that the expressions "amorphous phase" and "amorphous theory" might with justice be replaced by the expressions "colloidal phase" and "colloidal theory."

NATURE OF COLLOIDAL PARTICLES

To avoid misunderstanding, allow me to recall that any substance is in colloidal state when the constituent particles consist of molecular or atomic groups, whose size varies approximately from about 100 $\mu\mu$ down to about 1 $\mu\mu$ —that is, from just below the limit of microscopic resolvability down to the dimensions commonly ascribed to the larger molecules. It should be particularly noted that colloidalness involves no assumption as to the shape, internal structure or orientation of the colloidal particles, size alone being the critical factor. A colloidal system may therefore contain crystalline groups, or amorphous groups (non-crystalline, random or haphazard clusters), or a mixture of the two. Thus the recent observations of Scheerer² with the X-ray spectroscopy show that in certain gold and silver hydrosols the metal particles, including even those below the limit of ultramicroscopic visibility, consist of regularly oriented molecular groups—i.e., of tiny crystals, which show the same space lattice as macroscopic gold crystals. On the other hand, old specimens of silicic acid and stannic acid gels exhibit well-marked interference figures in addition to the characteristics of amorphous substances, and probably represent substances which are on the verge of crystallizing. Typical organic col-

loids, such as albumen, gelatin, casein, cellulose or starch appear to be truly amorphous.

Besides illustrating the point that a colloidal system may consist of crystalline or of non-crystalline groups, or of a mixture of the two, the results are of especial interest as showing the slow transformation, in the case of the silicic acid and stannic acid gels, of irregularly oriented into regularly oriented or crystalline groups, which indicates that the colloidal may be precursor of the crystalline condition.

ISOCOLLOIDS

All colloids consist of at least two phases—the subdivided substance, or "dispersed phase," and the substance into which this is subdivided, the "dispersion medium." It should be particularly remembered that it is not even necessary that there be any chemical difference between the dispersed phase and the dispersion medium. For example, there is here given³ in tabular form (Table I) a list of eight different "isocolloids" of water, where water forms both the phases.

TABLE I. WATER ISOCOLLOIDS

Dispersion Medium	Dispersed Phase	Example
(1) Solid ice....	Water vapor bubbles.....	Milk ice—turbid or milky white ice produced in refrigerating machines.
(2) Solid ice....	Liquid droplets of colloidal size.....	G. Quincke (Drude's <i>Ann. Phys.</i> , vol. 18, p. 11, (1905), regards this as the usual structure of solid, "amorphous" ice.
(3) Solid ice....	Solid ice in a colloidal degree of dispersion.	For proof of the existence of such systems, see G. Tammann, <i>Z. phys. Chem.</i> , vol. 69, p. 369 (1910); <i>anorg. Chem.</i> , vol. 63, p. 283 (1909). According to Quincke (1) and (2) may be converted into (3) by reduction of temperature.
(4) Fluid water	Water vapor bubbles of colloidal dimensions.....	Water, like other chemically homogeneous fluids near their critical vaporization temperature, shows turbidity, opalescence, varying density, etc.
(5) Fluid water	Fluid water droplets of colloidal dimensions.....	Ordinary water is supposed to consist of a mixture of associated group (polyhydrol) and unassociated groups. See H. Schade, <i>Koll. Zeit.</i> , vol. 7, p. 26 (1910) <i>Trans., Faraday Soc.</i> , vol. 6, pp. 71-129 (1910).
(6) Fluid water	Colloidally dispersed ice....	This dispersion is unstable and exists only as a transition form. "Snow-water" is a similar coarser dispersion. See P. P. von Weimarn and W. Ostwald, <i>Koll. Zeit.</i> , vol. 6, p. 181 (1910). Colloidal ice is readily produced in chloroform or ether (von Weimarn; <i>loc. cit.</i>) or in ice cream. (J. Alexander, <i>Koll. Zeit.</i> , vol. 4, p. 106 (1909).
(7) Water vapor	Colloidally dispersed water droplets.....	Fog, mist, clouds and (when coagulated) rain.
(8) Water vapor	Colloidally dispersed ice....	Fine snow or frozen fog, which in the upper atmosphere frequently produced a halo around the moon.

In addition to the ordinary ice referred to in Table I, there have been proved to exist at least four other kinds of ice, each heavier than water and stable only under the very high pressures at which they are formed.⁴ Since cooling and contracting metals exert a powerful

¹The present series of papers was written mainly in the fall of 1919. Reduced to about half their original form, they were read before the Columbus meeting of the American Institute of Mining and Metallurgical Engineers, October, 1920, and will so appear in vol. 64 of its *Proceedings*. They are now given in full, together with some recent additions which are indicated by enclosure within square brackets [].

*President, Uniform Adhesive Co., Brooklyn, N. Y. Member, Committee on the Chemistry of Colloids, National Research Council.

²See also J. Alexander, "Metals and Alloys From a Colloidal-Chemical Viewpoint" and discussion. *Trans. Am. Inst. Min. Eng.*, 1919.

³*Nachr. Ges. Wiss. Göttingen*, vol. 96, p. 100 (1913). *Chem. Abs.*, vol. 15, p. 2624.

⁴Adapted from Wolfgang Ostwald's "Handbook of Colloid Chemistry," p. 107, translated by M. H. Fischer (P. Blakiston & Sons Co., 1918). See also for example, W. E. S. Turner, "Molecular Association" (Longmans, Green & Co.), and H. Schade, *Koll. Zeit.*, vol. 7, p. 26 (1910).

⁵See P. W. Bridgman, *J. Frank. Inst.*, March, 1915, p. 315.

pressure upon their interior molecules, the question arises as to what extent this may influence their crystalline grouping. The fact that under uniform conditions one kind of ice formed in glass bulbs, whereas another variety formed in steel bulbs, seems to me to throw some light upon the effect of impurities in metals, for glass is slightly soluble in water at high pressure.* This relation is borne out by the fact that the presence of a few splinters of glass in the steel bulb, caused the appearance of ice V, the glass bulb variety. Bridgman's experiments also show that at 20,000 atmospheres pressure (about 300,000 lb. per sq.in.) paraffin and rubber actually become harder than is steel at the same pressure; further, that the expansive force exerted when water freezes into ordinary ice is about 30,000 lb. per sq.in. Water near the boiling point may be frozen by the application of a pressure of 20,000 kg. per sq.cm. As molecular forces are extremely powerful, we need not be surprised to find marked changes in the physical properties of metals to result from their application; and it is doubtful whether metal in the interior, especially of large masses, possesses the same properties as that on or near the surface, which alone is open to inspection.

ALLOTROPY OF ELEMENTS

Isocolloids may consist of a single element, in which case the dispersed and the dispersing phases are usually regarded as different allotropic forms of the element in question. Wo. Ostwald has proposed the term "allocolloids" for such systems, of which sulphur, selenium and phosphorus are typical examples. The relation to alpha, beta and gamma iron will at once occur to metallographists.

In describing the theory of dynamic allotropy W. E. S. Turner[†] says: "The fact that molecules of different kinds can co-exist in any liquid, the proportion of each depending on the temperature and other factors, has paved the way for a new view of allotropic modifications, according to which both forms can be present in a state of equilibrium. This theory has arisen more particularly as a result of the study of liquid sulphur, the abnormal behavior of which has been demonstrated to be due to a mixture of a mobile, yellow liquid called S_{λ} , which predominates in amount, and a viscous brown liquid S_{μ} , the proportion of which increases with rise of temperature and attains a proportion of 40 per cent at the boiling point, 455 deg. The two forms are further distinguished and rendered separable, and therefore capable of determination, by the fact that S_{λ} is soluble, while S_{μ} is insoluble in carbon bisulphide; indeed, corresponds in the quasi-solid form to the well-known amorphous sulphur. Certain reagents have the effect of stimulating the rate at which the equilibrium between the two forms is attained at a given temperature, other reagents retard the rate. Ammonia is such a stimulant, sulphur dioxide a retarder,[‡] and by the addition of the latter, the mixture can be cooled and afterward analyzed without the equilibrium set up at the higher temperature being disturbed. Sudden cooling by plunging into cold water will also retard the change and preserve the equilibrium proportions."

By pouring a thin stream of liquid sulphur heated to

400 deg. into liquid air, von Weimarn[§] obtained a perfectly transparent and exceedingly elastic sulphur. In this case the extreme speed of the chilling with the accompanying rapid increase in viscosity inhibits both the allotropic molecular rearrangement and also the colloidal aggregation, the resulting allocolloid being a very finely dispersed sulphur sulphogel or solid sulphosol. Of interest also as showing the influence of surface conditions is the fact that sulphur crystallizes from hot oil of turpentine in the form of monoclinic prismatic crystals (sp.gr. 1.98), which are unstable and transform into octahedral rhombic crystals (sp.gr. 2.05) with the evolution of heat, the transformation being facilitated by scratching or vibration, or by immersion in CS₂, in which the latter form is soluble, and from solutions of which it is deposited on slow evaporation of the solvent.

Phosphorus shows a variety of allotropic forms (or mixtures of a few); and from the evidence discussed by P. W. Bridgman,[¶] it seems obvious that ordinary red phosphorus consists of one allotropic form dispersed in another, the relative percentages depending upon the conditions of formation. In this paper Bridgman also describes a new black form of phosphorus (produced by pressure of 11,000 to 12,000 kg. per sq.cm. at 200 deg.), which is a fair conductor of electricity and has a sp.gr. of 2.691. White phosphorus has a sp.gr. of 1.83, red phosphorus a sp.gr. of 2.05 to 2.34 depending upon the method of its preparation; and both are perfect insulators. Thus, heating under high pressure results in an aggregation of some kind and gives phosphorus conductivity, a true metallic characteristic. In metals, a similar aggregation seems to occur because of the enormous cohesion or molecular attractive forces of the metal molecules themselves—a property made use of in shrinking on collars and the like and even in straightening the bulging walls of buildings by the shrinking of heated iron rods.

MECHANISM OF SOLIDIFICATION

When a metal is heated to fusion, the thermal agitation of its molecules is sufficient to overbalance, at least to some extent, the mutual attraction of its molecules; but this does not mean that the strong aggregation tendency of its molecules is without effect. On the contrary, in the state of kinetic equilibrium which exists, there must be a certain number of molecular groups, whose size and number tend to increase as the solidification point is approached—that is, as the thermal agitation diminishes. The higher the temperature to which the metal is heated and the quicker it traverses the zone of intense thermal agitation to the comparative quiet of solidification the smaller and more numerous will be the molecular groups. The general tendency seems to be for atoms or simple molecules to form crystals, whereas complicated molecules—especially those with several foci of attraction, like gelatine—tend to remain in random or colloidal clusters. Although Traube's experiments^{||} indicate that liquid zinc, cadmium and mercury are monatomic, it is probable that investigation will show that all metals near their freezing points, and especially metals of high melting points, exhibit molecular association or else allotropism.

It would appear then that just prior to solidification and crystallization all pure metals are isocolloids—that

*The indications are that in volcanic depths, where high pressures and high temperatures exist, water and silicates exist as a jelly-like solid, which explodes into colloidal fragments upon sudden release, as at the eruption of Mt. Pelée at Martinique.

†"Molecular Association," p. 92. Longmans, Green & Co., 1915.

‡Note the analogy to the effect of Mn in steel.

§Koll. Zeit., vol. 6, p. 250 (1910).

¶J. Am. Chem. Soc., vol. 36, pp. 1344-1363 (1914).

||Ber., vol. 31, p. 1562 (1898). W. E. S. Turner, citation (3), p. 53.

is, they consist of colloidal sized groups of metal molecules distributed in a more completely dispersed magma. But the dense concentration and proximity of their molecules, their powerful molecular attractive forces (their cohesion, to which they owe their strength and strong crystallization tendency) act so rapidly that, as a general rule, the major portion of the metal forms macroscopic or microscopic crystals, which are embedded in an intercrystalline network consisting mainly of colloiddally dispersed metal having different physical properties from the crystals, of whose creation it constitutes a remaining vestige. While a fluid metal may contain a percentage of isolated molecules, it does not seem possible that many of these remain in the solidified metal, which consists mainly of macro- and microcrystals, and of oriented and unoriented groups of colloidal dimensions. Thus not even the most rapid chilling prevents non-magnetic γ iron from becoming magnetic, although at the temperature of transformation the metal is no longer fluid.

EFFECT OF GRAIN SIZE

The more rapidly the fused metal is chilled the less opportunity there is for the growth of crystals beyond the colloidal stage—it is well known that quick cooling yields fine structure. The effect of quick chilling on the hardness and specific gravity of metals is illustrated by the following results, kindly worked out by W. A. Cowan of the National Lead Co.'s research laboratory. The chill castings were made in a water-jacketed cylindrical mold and measured 2 in. in diameter by 1 in. high. The slowly cooled specimens were of the same size and shape, but were cast in a hot mold, taking 12 minutes to solidify after casting from a moderate temperature. Small vertical sections, weighing about 20 g., were cut radially from the ingots, and the specific gravity of these was determined by immersion in distilled water, with weighings before and after. Before making the hardness tests, both sides of the ingots were machined flat, $\frac{1}{8}$ in. being removed from the bottom for testing surfaces. The results follow:

	Sp.Gr.	Brinell Hardness Numbers
Straite tin, chill cast.....	7.309	8.8
Straite tin, slowly cooled.....	7.301	7.7
Corroding lead, chill cast.....	11.367	5.2
Corroding lead, slowly cooled.....	11.354	4.4

As the differences between the melting and chilling temperatures in these experiments is, for metals, rather narrow, further tests are being made using liquid air as a chilling medium.

The results of quick chilling are analogous to those of cold hammering, which shatters the large grains and increases the percentage of colloidal metal present. Thus Zay Jeffries¹¹ reports the following results:

	Brinell Hardness Numbers
Cast tin, large grain.....	9.12
Cold-hammered tin.....	11.32
Cast lead, large grain.....	5.44
Cold-hammered lead.....	6.54

Much regarding the minute structure of metals may be determined by metallography, which involves the microscopic examination of suitably polished and etched metallic surfaces. Metallography has been most fruitful of results, and much of our present knowledge of metals and alloys has been attained with its aid, particularly knowledge of the crystalline phase or "grain."

Of the so-called amorphous or colloidal phase, however, metallography can tell us but little outside of its occurrence and distribution. Owing to the great opacity of solid metals, it has thus far been impossible to subject the colloidal phase to successful ultramicroscopic examination, and such examinations of thin films along the lines laid out by Beilby present difficulties and cannot apply to the mass, although they may be of interest.

SIMILARITIES BETWEEN HOT GLASS AND HOT METAL

But glass may be readily examined ultramicroscopically, and a consideration of the phenomena observed in glasses will serve for the present to give some insight into what occurs in metals and alloys."

Among glass technologists a molten batch of glass is termed "metal," a term remarkably well chosen, for, strange as it may appear, there are numerous analogies between glasses and most metals. Both are produced or fused at high temperatures, and as they issue from the furnaces are, for the most part, heavy viscous liquids" prone to set and crystallize. Both exhibit the phenomena of supercooling to a marked degree if quickly chilled. Both may be cast, molded, pressed, drawn and annealed or tempered—they are in fact thermoplastic and their physical properties are largely dependent upon their thermal and mechanical histories. There are, of course, many enormous differences between glasses and metals, and very marked differences exist even in their analogous properties. Thus with metals the crystallization tendency is powerful and quick acting, whereas with glasses the composition is generally chosen so as to prevent crystallization under operating conditions, some of the constituents of glass apparently serving as protectors or inhibitors of crystallization toward the others. Furthermore, metals tend to cool much more rapidly than glasses because of their greater thermal conductivity; but their rapid crystallization usually outstrips their chilling, notwithstanding the fact that the latter is often facilitated by quenching.

BEHAVIOR OF SUPERCOOLED MELTS

As Tammann has shown," there are three main factors which control the behavior of supercooled melts: (1) The specific crystallization capacity (which is measured by the number of centers of crystallization formed in a unit mass in a unit time); (2) the speed of crystallization; (3) the variation in viscosity. In the case of the various mixtures of fused silicates composing molten glasses, the viscosity increases so rapidly upon cooling that the crystallization forces are unable to establish themselves before the melt becomes too rigid to permit molecular orientation. The result is the amorphous, or colloidal, mass we call glass. In very quickly cooled glass—i.e., Prince Rupert bubbles—the internal strains are so great that the glass is actually explosive; and in the ordinary process of manufacture glass has to be annealed to render it less brittle. This is accomplished by cooling the glass very slowly, keeping it at a low heat for a long time so that there may be a partial adjustment of the aggregation tendencies of its particles. Gelatin jellies act similarly, but, because of their softness, anneal spontaneously at room tempera-

¹¹For results of ultramicroscopic examination of quickly and slowly chilled soaps, see J. Alexander, *Trans. Am. Inst. Min. Eng.*, 1919; *J. Soc. Chem. Ind.*, 1909; *Trans. Am. Inst. Chem. Eng.*, vol. 2, pp. 210-228 (1909).

¹²[Truly liquid metals have a low viscosity. See abstract of Prof. T. Turner, *J. Soc. Chem. Ind.*, vol. 40, p. 190R (1921).]

¹³*Z. Elektrochim.*, vol. 10, p. 502 (1904).

¹¹*J. Am. Inst. Metals*, vol. 11, p. 318.

ture." Thus F. Stoffel¹² has shown that quickly cooled gelatin jellies permit the more rapid diffusion of electrolytes than slowly cooled jellies; but the difference equalizes itself after several days. Incidentally this shows the higher dispersion of the particles in the quickly cooled jelly and the greater total area of diffusion paths.

If the composition or heat-treatment of the glass is such that crystallization occurs, we call the phenomenon devitrification—the glass becomes cloudy or opaque. The inherent tendency toward crystallization exists even in clear glasses, and may be realized after a very long lapse of time. [The composition of opaque glasses is so chosen that under usual conditions a turbidity is produced, a fine precipitate which renders the glass opaque. Recently James Gillinder, of Port Jervis, N. Y., was kind enough to make for me some Prince Rupert drops from a batch of opal glass. The exterior rind of the drops was clear or showed a faint turbidity, whereas the interior, which was of course more slowly cooled, was milky and opaque. At the surface the chilling was from about 1,200 deg. down to 15 or 20 deg.] Thus ancient Egyptian and Roman glasses are frequently found to be devitrified. On the other hand, although old leaden roofs consist of metal showing coarse crystals, ancient iron shows practically the same structure as modern iron. We must remember that iron as a rule consists mainly of the crystalline phase, which is stable, not of the colloidal phase, which is metastable and can undergo slow hysteresis; besides, iron does not undergo annealing at ordinary temperatures.

GOLD RUBY GLASS

The work of Zsigmondy, on gold ruby glass,¹³ has given us an understanding of what happens when a metal is dispersed in glass. When gold is added to a glass melt (usually 1 part of gold chloride to from 3,000 to 10,000 glass), it dissolves, and the molten glass is colorless and upon slow cooling may become red or remain colorless, depending upon the nature of the batch. If quickly cooled to a set, all grades of gold ruby glass remain colorless. Upon reheating colorless ruby glass to the softening point, a portion of the dissolved or molecularly dispersed gold separates out upon nuclei or crystallization centers already formed in the

quickly than they had previously been chilled; they were heated so that at one end they began to melt (hot end), whereas at the other end they remained cold (cold end).

That with these particular specimens no new crystallization nuclei were formed upon reheating is evident from the fact that the average distance between the ultramicros was the same in the intensely heated portions as in the less heated portions of the glass. "Colorless, slowly cooled gold ruby glass contains one part of its gold, therefore, in supersaturated solution, and the remainder in the form of nuclei so small that they affect the homogeneity of the glass only slightly or not at all. With batches of different composition, the temperature for the spontaneous formation of nuclei is so much higher that such glass colors up red on slow cooling."

Applying these principles to technical practice, Zsigmondy was able to explain certain heretofore incomprehensible observations. Thus, "The rim of a piece of pressed ruby glass remained colorless, while the middle became red. In the press the rim was more quickly cooled than the middle, and by subsequent heating was heated more quickly and to a higher temperature. Investigation showed that the rim contained a much lesser number but considerably larger green gold particles than the rest of the glass. The rim of the glass had very quickly passed through the optimum temperature for the formation of nuclei, so that only few were formed; subsequent heating to a higher temperature, therefore, led to a speedy growth of these nuclei into particles of 110 to 145 μ . The middle section of the glass had time enough to form a large number of nuclei, which, being less strongly heated, grew more slowly. In spoiled ruby glass the formation as well as the growth of nuclei is disturbed; fewer nuclei are formed and these grow more slowly than in good ruby glass."

DEVITRIFICATION OF GLASS

Zsigmondy emphasizes the fact that the coloring of ruby glass should not be confounded with ordinary devitrification. "The difference between the two is that in the formation of ruby glass several milliards of nuclei exist and grow in a cubic millimeter, and that the hypothetical little crystals, of whose form and structure we know nothing, are so small that their presence changes only the visible appearance and not the working properties of the glass; whereas, in the case of devitrification, relatively few nuclei are present and lead to the formation of quite large crystals, which prevent the usual working up of the glass."

This difference is clearly seen on considering the facts brought out by N. L. Bowen in a recent paper¹⁴ on the devitrification of glass. While many silicates may be cooled quite slowly without crystallizing, MgSiO_3 , Al_2SiO_5 , and CaSiO_3 crystallize unless quickly chilled, a condition difficult of realization because molten silicates combine high thermal capacity with low thermal conductivity. The composition of the batch must be chosen to prevent supersaturation with any component at any temperature at which the glass is to be subsequently maintained. If devitrification occurs when the glass is cooled preparatory to working (or prior to the final stirring in the case of optical glass), the crystals formed are usually large. When the glass is cooled from the plastic to the rigid state, as during

TABLE II.

Hot End	Color Red Decreasing	Good Ruby Glass	Color Decreases	Spoiled Ruby Glass
a		Color intense red. Numerous green ultramicros, very close together, their brightness diminishing.		Color blue. Ultramicros fewer, copper-red, further apart.
b				Color violet. Ultramicros yellow.
b'				Color bright red. Ultramicros green.
c		Homogeneous green light cone		
d		Colorless and homogeneous.		Colorless. Few faint specks visible.
Cold End				

previously chilled mass, and the glass usually develops its normal red color. Spoiled batches, upon reheating, generally yield a blue or violet shade, but may yield an unsatisfactory red. Reproduced in Table II are the ultramicroscopic observations of Zsigmondy made upon good and upon spoiled ruby glass, using bright sunlight and a homogeneous immersion objective. Both specimens had been slowly cooled and then reheated more

¹²So do soft metals; lead and tin, for example.

¹³See H. Bechhold, "Colloids in Biology and Medicine," p. 52, translated by J. G. M. Bullowa. (D. Van Nostrand Co., 1919.)

¹⁴"Colloids and the Ultramicroscope," (translation by J. Alexander). John Wiley & Sons Co., 1909.

¹⁵J. Am. Ceramic Soc., vol. 2, pp. 261-261 (1919).

blowing, drawing, casting and particularly when optical glass is being cooled in the melting pots, devitrification may occur through the separation of spherulites or minute crystals uniformly disseminated throughout the glass, making it opalescent. Microscopically these crystals were found to be trydymite and cristobalite in most cases investigated. Particularly interesting is the fact that their formation is facilitated by "mineralizers" such as SO₂ or Cl₂; arsenic acts similarly if in excess, and fluorine may do so. This reminds one of a "salting out" action; the opposite or protective action of constituents in a melt is illustrated by the facts brought out in a paper¹³ by H. F. Bellamy on gold ruby glass. His results show that SnO₂ acts as a powerful protector or stabilizer, deepening the color of the glass to such an extent when added in optimum proportions that the percentage of gold present has to be diminished.

The tin also keeps the color uniform over a range of reheating temperatures and prevents the development of light blue, purple or rose colors (which are indicative of coagulation or undue aggregation).

We have here a typical instance of protection in the colloidal sense, which is quite in line with the work of Zsigmondy,¹⁴ who showed that the purple of Cassius (an ammonia-soluble deep red precipitate obtained by mixing solutions of chloride of gold and stannous chloride) is simply colloidal gold stabilized by colloidal stannic acid. Berzelius regarded the purple of Cassius as a chemical combination of tin sesquioxide and purplish oxide of gold, and Gay-Lussac, Debray, Müller and others contributed to the extensive literature concerning it. Zsigmondy settled the moot question, for he actually synthesized the purple of Cassius by mixing together the hydrosols of gold and stannic acid, thus proving it to be an adsorption compound of the two. (Part II, dealing with Crystallization, will appear in a subsequent issue.)

The Claude Ammonia Process

AT A joint meeting of the Chemical Engineering Group of the Society of Chemical Industry and the Institution of Mechanical Engineers recently, J. H. West read a paper on the Claude synthetic ammonia process and plant, published in abstract in the Dec. 9, 1921, issue of *Iron and Coal Trades Review*. The author is associated with the Cumberland Coal Power & Chemical Co., which is erecting works at Workington to operate the process. The company has acquired three collieries in Cumberland, whose coke ovens are capable of making 3,000 tons of coke per day. With the view of obtaining a supply of hydrogen immediately and under the best conditions, a controlling interest has been acquired in the Tysse Water Power Co., in Norway, which has a plant of a capacity of 145,000 electrical hp. The cost of power for the production of hydrogen is about £1 per hp.-yr., or 0.04d. per kw.-hr. This acquisition also gives the company rights over the carbide factories at Odda, and with these means for the production of hydrogen it will be able to get to work more quickly than by producing the hydrogen in this country. The electrolytic-hydrogen plant in Norway has a daily capacity of over 9,000,000 cu.ft.

Claude's experimental work has shown very clearly that for a given temperature the proportion of nitrogen

and hydrogen remaining combined under conditions of equilibrium increases rapidly with rise of pressure, and that the lower the temperature the higher is the proportion of combination. However, the lower the temperature the longer it takes to reach equilibrium, so that a compromise is necessary. Claude finds it best to work at 600 deg., and he uses a pressure of 900 atm., or nearly 6 tons per sq.in., as against the 200 atm. used by Haber. The hydrogen and nitrogen, mixed in the proper proportions, are first compressed to 100 atm. in an ordinary three- or four-stage compressor, passed through separating bottles, where any condensed moisture and oil from the compressor are drained off, and the gas mixture thence goes to the supercompressor. This is a simple two-stage machine capable of dealing with enough gas to make 5 tons of liquid ammonia per 24 hours—i.e., 426 cu.ft. per minute. One of these machines has been running in France for 9 months without trouble.

SMALL PIPE-WORK FACILITATES GAS-TIGHT JOINTS

An important result of working at superpressure is that the pipe-work becomes small; the pipes carrying the mixed nitrogen and hydrogen for a plant making 5 tons of ammonia per day are only 8 mm. bore, and the difficulty of making gas-tight joints is thereby greatly reduced.

Quite small catalyst vessels can be used which can be heated initially by external electric circuits, and after that the problem is to get rid of the excess heat. A Haber catalyst vessel for 20 tons of ammonia per day weighs 74½ tons, against 11½ tons for Claude tubes. In the Claude plant there are four catalyst tubes, the first two of which are parallel, and the other two in series with the first two and with each other. The Claude tubes are of special chromium alloy without a lining. Some of these tubes have been made in France, and some in England by Messrs. Vickers, who use a metal called Vicronic which is said to have remarkable heat-resisting properties. The tubes are cast solid and bored out. The basis of the catalyst used by Claude is peroxidized iron prepared by burning iron in oxygen, with the addition of other equally cheap materials which are added in order to increase its activity and immunity from poisons.

Another important detail in the Claude process is the manner of removing the ammonia from the catalyst tubes. Under the Haber conditions it is necessary to inject water into the system and thereby recover the ammonia as an aqueous solution, leading to consumption of power and plant complication. At 900 atm., however, simple cooling by a coil immersed in water suffices to liquefy the whole of the ammonia with the exception of 2 or 3 per cent, and this small quantity is easily removed from the residual gases either by further cooling produced by the vaporization of part of the ammonia or by absorption in sulphuric acid.

Cheap hydrogen is essential to the commercial success of synthetic ammonia and the most economical source at present is the existing coke ovens. In countries where cheap water power is available electrolytic hydrogen becomes attractive.

The packing of the stuffing boxes in the Claude apparatus is merely a single hydraulic leather. The Haber plant requires three days to heat up after being allowed to get cold, whereas the Claude plant will begin to produce again in four to five hours. The tubes in the Claude process are encased in ferro-concrete containers for safety.

¹³J. Am. Ceramic Soc., vol. 2, pp. 313-322 (1919).

¹⁴Colloids and the Ultramicroscope, p. 85. E. A. Schneider anticipated Zsigmondy, whose discovery, however, was made independently.

Notes on the Chemistry of Chromyl Chloride

BY ELTON RICHMOND DARLING

THE experimental work which is being carried out with chromyl chloride, CrO_2Cl_2 , in the manufacture of organic dyes and compounds gives evidence of its greater use.

The literature on the subject is not extensive and the following notes may be of service to those interested.

The first mention in the literature of chromyl chloride is that of Thomsen (*Phil. Trans.*, 1827, p. 159), who claimed to be its discoverer. Thomsen prepared it by fusing a mixture of 20 parts of sodium chloride and 24 parts of potassium bichromate with 60 parts of concentrated sulphuric acid. It was purified by repeated crystallization. He also prepared it by heating chromium trioxide in a current of hydrochloric acid and distilling to separate the chlorochromic acid which was also formed. This product was investigated by Berzelius and Wöhler (*Pogg. Ann.*, 1834, vol. 33, p. 343).

Geuther (*Ann.*, vol. 106, p. 239) prepared it by heating equal parts of chromic anhydride and ferric chloride together in a retort. He also prepared it (*Ann.*, vol. 118, p. 69) when chromic anhydride and chromic chloride were heated together in a ratio of 2 parts of the former to 3 parts of the latter.

Schiff (*Ann.*, vol. 106, p. 116) prepared it by heating 1 part of chromic anhydride and 2 parts of phosphorus pentachloride together. He further stated that it could be prepared (*Ber.*, vol. 10, p. 104) by suspending chromic anhydride in concentrated sulphuric acid and passing in hydrogen chloride.

Moissan (*Ann. Chim.* (6), vol. 5, p. 568) prepared it by passing hydrogen chloride over chromic anhydride.

Etard (*Ann. Chim.*, vol. 5, p. 218) prepared it by the method of Thomsen and obtained a yield of 70 per cent of theory. He carried out the distillation several times in the presence of carbon dioxide gas.

E. Moles and L. Gomez (*Z. physik. Chem.*, vol. 80, pp. 513-30) prepared the chromyl chloride by the method of Thomsen except they used fuming sulphuric acid in place of the ordinary sulphuric acid.

H. Moissan (*Compt. rend.*, vol. 98, pp. 1581-1583) prepared it by submitting chromic anhydride to the action of a mixture of chlorine and hydrochloric acid and then heating the whole to 150 deg. C. He further states that the chromates of the alkalis, barium, lead and silver all give chromyl chloride when treated with hydrogen chloride. He further states (*Bull. Soc. Chim.*, vol. 43, p. 6) that it can be prepared by using chlorine and steam in place of the hydrochloric acid, but the reaction is not possible if only the dry chlorine is used.

H. D. Low and F. M. Perkins (*Proc. Chem. Soc.*, vol. 23, p. 11) obtained a nearly theoretical yield by dissolving chromic acid in more than the equivalent of concentrated hydrochloric acid and then adding to the solution concentrated sulphuric acid in small amounts until the chromyl chloride separated out as a heavy underlayer which was drawn off. This was purified by blowing air through it and then distilling.

Thomsen (*Phil. Mag.*, 1827, p. 452) prepared ammonium chloride from chromyl chloride by passing its vapors into a vessel of dry ammonia gas. This was, however, but one of the products formed.

Wöhler (*Ann.*, vol. 60, p. 203) found that upon heating chromyl chloride to a dull red heat it was decom-

posed, splitting up into chromic oxide, oxygen and chlorine.

V. Thomas (*Compt. rend.*, 1899, vol. 129, pp. 828-831) treated chromyl chloride with nitric acid, which resulted in the formation of higher nitrogen oxides. He then investigated and studied a series of double compounds prepared from it.

Liebig (*Pogg. Ann.*, vol. 21, p. 359) in carrying out some research work on chromyl chloride believed that he had prepared metallic chromium when brown fumes resulting from the action of chromyl chloride vapors upon dry ammonia were obtained.

G. Odde and E. Serra (*Gazz. chim. ital.*, 1899, vol. 29, ii, pp. 318-329) carried out work on the polymerization of inorganic chloro-anhydrides.

P. Pascal (*Compt. rend.*, 1909, vol. 148, pp. 1463-1465) treated chromyl chloride with dry nitric oxide and produced chromyl subchloride. This product he found to possess strong magnetic properties.

G. G. Henders and I. M. Heilbron (*J. Chem. Soc.*, vol. 99, pp. 1887-1901), in their work on the chemistry of the terpenes, investigated the action of chromyl chloride upon bornylene.

C. Pagel (*Chem. Centr.*, 1900, vol. 2, p. 784) used chromyl chloride to destroy organic substances in toxicological analysis.

Sell (*Proc. Roy. Soc.*, vol. 33, p. 267) found that no chlorine was formed when chromyl chloride was heated with carbamide.

R. F. Weinland and M. Fiederer (*Ber.*, 1906, vol. 39, pp. 4042-4047) found that when the chlorides of the alkali metals were treated with chromyl chloride double salts were formed.

E. Beckmann (*Z. anorg. Chem.*, vol. 77, pp. 90-102) studied chromyl chloride as an ebullioscopic solvent.

E. Moles and L. Gomez (*Anales soc. españ. fis. quim.*, vol. 12, pp. 142-154) made extensive studies regarding the properties of chromyl chloride and its action toward various chemicals.

S. Rideal (*J. Chem. Soc.*, 1886, vol. 49, pp. 367-368) made a quantitative study of the action of ammonia upon chromyl dichloride.

D. Spense and J. C. Galletly (*J. Am. Chem. Soc.*, vol. 33, pp. 190-194) noted that as a result of treating various rubbers of different botanical origin with chromyl chloride a compound was formed which was analogous to a compound that resulted when terpenes were similarly treated.

A. Haller (*Compt. rend.*, vol. 84, pp. 558-559) prepared anthraquinone by dissolving anthracene in glacial acetic acid and treating this to the action of chromyl chloride.

H. S. Frey and J. L. Donnelly (*J. Am. Chem. Soc.*, 1918, vol. 40, pp. 478-482) studied the action of chromyl chloride upon phosphorus halides dissolved in carbon tetrachloride so as to prevent any explosion from taking place. This was a continuation of an earlier work (*J. Am. Chem. Soc.*, 1916, vol. 38, pp. 1923-1928).

H. Quantin (*Compt. rend.*, vol. 104, pp. 223-224) prepared phosgene by the action of carbon tetrachloride upon chromyl chloride. He also noted that carbon monoxide decomposed it with the formation of chromic oxide and chromic chloride.

Jose R. Mourele and A. G. Banus (*Anales soc. españ. fis. quim.*, vol. 9, pp. 355-362) were unsuccessful in their attempt to prepare phosgene by the action of carbon upon chromyl chloride. The products formed were chromic anhydride and chromic chloride.

Corrosion of a Producer-Gas Cooling System

Cooling Water of High Acidity and Containing Much Dissolved Oxygen and Suspended Coke Dust Causes Deterioration of Cooling System at the Plant of the Providence Gas Co., Providence, R. I.—Remedial Measures Are Suggested*

BY LLOYD E. JACKSON

THE manufacturing plant of the Providence Gas Co. has been described in detail in articles published recently.¹ It is sufficient to mention here that the plant as a whole consists of coal-gas and water-gas plants, with auxiliary equipment necessary for their operation.

The gas producers, five in number, were designed to produce gas from coke or from bituminous coal, either with or without recovery of ammonia. However, under existing conditions, the producer plant did not operate successfully with bituminous coal. Some minor changes were made and the producers were put in operation again with small-size coke for fuel instead of bituminous coal. After six months' operation with coke, leaks developed in the producer-gas cooling-water system and a thorough investigation was undertaken to determine the causes and remedies for the deterioration of the piping and other iron parts. The writer, an Industrial Fellow of the Mellon Institute of Industrial Research of the University of Pittsburgh, was assigned to conduct the investigation, and it is the purpose of this article to discuss the results of eight months of extensive tests, analyses and observations.

enters the system over the tops of the producers and through the separator. During the eight months of testing, one leak, the first in that line, developed in the 10-in. pipe line conveying cooled water from the coke filters to the producer plant. Leaks occurred in the small distributing pipes which carry cool water to the dust catcher and collecting main and condenser sprays. Most of the leaks developed in the 6-in. pipe line which conveyed warm water from the decanter to the cooling pond, a distance of approximately 550 ft. It has been necessary to renew every piece of this pipe line at least once and parts of it have been renewed twice. The impellers in the centrifugal pumps which pump the cooling water to and from the cooling pond also gave considerable trouble. Those in the pumps pushing water from the decanter to the cooling pond had to be renewed more frequently than those bringing water back.

FOUR POSSIBLE CAUSES FOR THE DETERIORATION

It was decided that the deterioration of the cooling-water system could be due to any one or a combination of two or more of four causes, as follows: (1) electrolysis caused by stray electric currents; (2) free



FIG. 1. PANORAMIC VIEW OF THE PLANT OF THE PROVIDENCE GAS CO., PROVIDENCE, R. I.

Fig. 4 is a line-drawing of the producer-gas cooling system as the plant was operating when the greatest number of leaks developed. Starting at the coke filters near the spray pond, cool water is distributed to the dust catcher, collecting main and condenser sprays. From here the water, after coming in contact with the hot producer gas, falls into the decanter below and is pumped to the spray pond, cooled, and again pumped through the same cycle. Make-up water from the city water mains

mineral acid; (3) suspended erosive matter, and (4) dissolved oxygen. Observations made from time to time during the investigation tended to discourage the probability of stray currents being a factor in the problem. In the first place, tests with a millivoltmeter failed to indicate any difference in potential between various parts of the piping system. In the second place, the general nature of the corrosion was not characteristic of electrolysis by stray currents. Corrosion of pipe lines due to stray currents causes very rapid corrosion at points where the current leaves the line, while at other places in the line the pipe will appear practically untouched. If the producer-gas cooling-water pipes carried a stray electric current, that current would have

*Published by permission of the Providence Gas Co., Providence, R. I., under whose auspices the research was conducted at the Mellon Institute of Industrial Research of the University of Pittsburgh, Pa.

¹Russell, *CHRM. & MET. ENG.*, vol. 21 (1919), pp. 34, 38 and 147; and Bauer, *Gas Age*, vol. 43 (1919), pp. 46 and 516.

TABLE I. MINERAL ANALYSES OF WATER COLLECTED FROM THE PRODUCER-GAS COOLING SYSTEM (PARTS PER MILLION)

Sample No. (See Fig. 4)...	1	2	3	4	5	6	7
Source - Filtered Samples From.....	Decanter Near Intake Spray Pond Pump	Weir Near Prod.-Gas House	Overflow Ash Pan Prod. No. 1	Decanter After Condenser	Left Coke Filter	City Water	Narragansett Bay Water
Silica.....	9	10	9	14	9	1	16
Iron.....	25	29	22	31	29	1	4
Calcium.....	10	14	33	11	10	4	260
Magnesium.....	3	3	22	3	4	2	790
Sodium.....	84	71	1	81	69	1	6,600
Chlorides.....	80	53	5	60	53	8	11,500
Sulphates.....	131	147	15	153	135	9	1,467
Total solids.....	442	327	39	353	311	26	20,317
Acidity as calcium carbonate.....	16	11	..	19	12	..	.....
Alkalinity as calcium carbonate.....	..	..	14	..	..	17	82

to enter and leave the line at certain points. At the point or points where it would leave the line, marked corrosion would take place both on the outside and inside of the pipe, while other parts of the line would last indefinitely. Furthermore, if corrosion were caused by stray currents, the pipe line from the producer plant to the cooling pond would not corrode so much more rapidly than the pipe line conveying the water from the cooling pond to the producer plant. One more argument, and a convincing one, against the probabilities of stray currents being a factor in the problem is the fact that during the time that the plant has operated with bay water for producer-gas cooling, which totals almost five months, fewer leaks have developed than was the case with fresh water. If the pipe lines were carrying stray currents, the much greater concentration of dissolved salts in bay water would tend to increase cor-

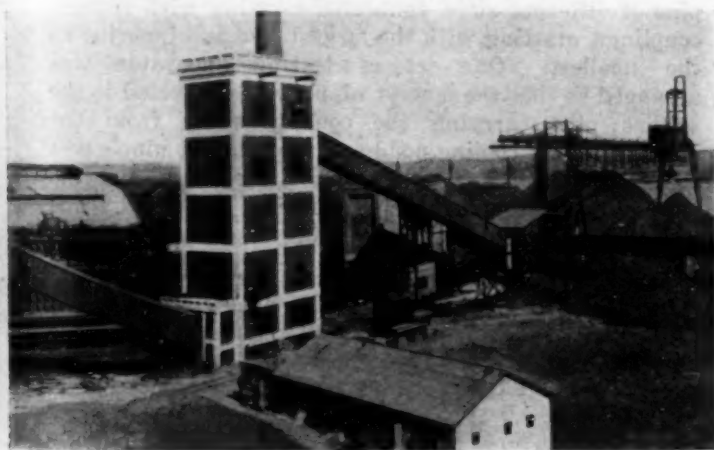


FIG. 2. CRUSHER BUILDING AND COAL-CONVEYING MACHINERY

rosion greatly and develop more leaks than would develop with fresh water.

As a step to determine the cause of the trouble, samples of water were collected from the producer-gas cooling system at the places marked in Fig. 4 with numbered arrows. Complete mineral analyses of these samples were made and the results are presented in Table I.

One of the characteristic properties of the cooling water which might cause corrosion is acidity. Acid was found not only in the samples analyzed and reported in Table I, but also in numerous check samples collected later. It is well known that even traces of free mineral acids in water cause the rapid corrosion of pipe lines

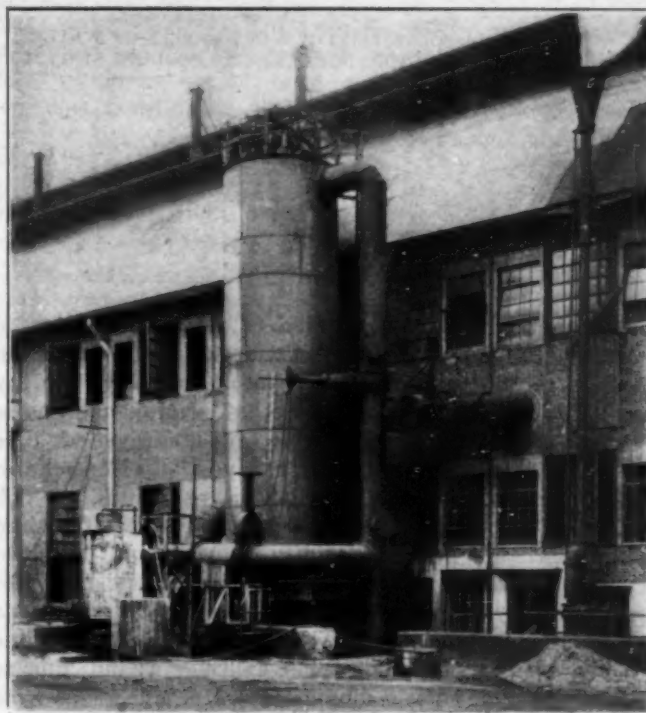


FIG. 3. EXTERIOR OF THE PRODUCER-GAS PLANT, SHOWING CONDENSER, EXPERIMENTAL LIME-TREATING APPARATUS AND DECANter

carrying it. The most economical way to treat acid water is to neutralize it with lime, but before starting to treat the water to correct its corrosive properties, some carefully cleaned test-pieces of iron, 5 in. x 2 in. x 1/2 in., were suspended by means of a piece of wrapping cord in the cooling system at the same points from which water samples were collected. The test-pieces were allowed to remain several days and then were removed, dried and weighed. Losses per sq.in. of exposed surface were calculated and the results are presented as test 1 in Table II. This test was made to obtain data with which to compare future data to be obtained from tests made following successive steps in treating.

Apparatus to treat the water with lime next was installed. At first the water was treated with sufficient lime to make it alkaline to methyl orange indicator. During this time the same test-pieces of iron were suspended in the cooling system at the same points as described for test 1. The weights lost per 24 hours per sq.in. of exposed surface are shown by test 2 in Table II. The results of these two tests show that the corrosion of iron is about one-half as great when the water

TABLE II. CORROSION TESTS ON PIECES OF IRON. (MILLIGRAMS OF WEIGHT LOST PER SQ.IN. PER 24-HR.)

Cooling Medium	Test No.	End of Decan- ter Intake to Spray Pond Pump	Decanter Near Condenser	Weir From Prod. House	Before Steel Turnings Filter	After Steel Turnings Filter
Recirculated City water not treated; test 7/12 to 7/16/20.....	1	15.2	29.4	11.5	8.3	...
Recirculated City water alkaline to methyl orange; not deactivated; test 10/13 to 10/16/20.....	2	7.4	19.3	4.6	4.6	3.7
Recirculated City water alkaline to methyl orange, deactivated; test 10/25 to 11/3/20.....	3	3.6	4.7	3.1	5.6	2.6
Bay Water Deactivated Test 8/25 to 9/1/20.....	4	4.0	14.4	5.2	1.7	0.0

TABLE III. DISSOLVED OXYGEN IN SAMPLES OF WATER COLLECTED FROM THE PRODUCER-GAS COOLING SYSTEM

Location	City Water Tap in Exhauster Room	Intake Spray Pond Pump	Weir From Prod. House	Overflow From Ash Pan	Decanter After Condenser	Left Coke Filter
Temperature (deg. F.)	73	122	131	136	131	93
Dissolved oxygen (p.p.m.)	4.6	2.3	2.2	3.8	1.4	5.2

is treated with sufficient lime to make it alkaline to methyl orange. Figuring the quantity of lime used on a basis of 100 per cent CaO, from 50 to 100 lb. per day was required to maintain the decanter water alkaline to methyl orange. The variation in quantity of lime required was due to operating conditions in the producers and to the number of producers in line.

Methyl orange indicates free mineral acid only, while phenolphthalein shows acidity caused by dissolved carbon dioxide as well as the free mineral acid resulting from the hydrolysis of iron salts. An attempt was made to treat the decanter water with sufficient lime to maintain it alkaline to phenolphthalein; but, due to the presence of carbon dioxide in the producer gas with

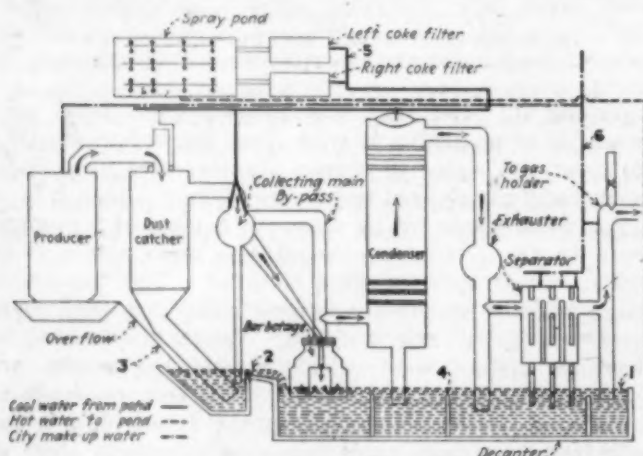


FIG. 4. PRODUCER-GAS COOLING SYSTEM. NUMBERS INDICATE POINTS AT WHICH WATER SAMPLES WERE TAKEN

which the cooling water came in direct contact, so much lime was required to maintain the water alkaline to phenolphthalein that it was not considered a practical method of treatment.

About the same time that samples were collected for mineral analyses more samples were taken from the decanter at the same points and analyzed for dissolved oxygen. The results are presented in Table III.

Many more samples were later collected from the cooling-water system and tested for dissolved oxygen. The results obtained were practically the same as reported in Table III. These tests indicated that the city water used for making up evaporation losses was highly saturated with dissolved oxygen. It is also evident that, as the water gives up its dissolved oxygen in the gas-cooling system, it is continually receiving a fresh charge when it is sprayed into the cooling pond.

It is a fact that dissolved oxygen is an active corrosive agent either in a neutral or acid solution. It is particularly active in the presence of free mineral acids. To free the cooling water of dissolved oxygen, it was proposed that the coke in the coke filters be replaced by steel turnings. The dissolved oxygen in the water flow-

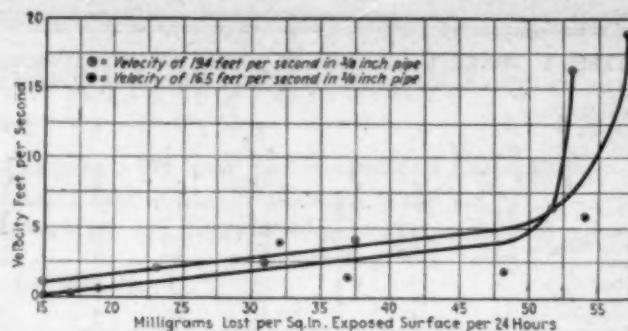


FIG. 5. EROSION ACTION OF COOLING WATER CONTAINING SUSPENDED COKE DUST

ing from the cooling pond through the steel turnings combines with iron to form iron oxide and the water is pumped from the filters oxygen free. Test-pieces of iron suspended in the cooling system, after the installation of the steel-turnings filter, corroded as shown by the results tabulated under test 3 in Table II. For purposes of comparison, test-pieces hung in the decanter near the intake to the cooling pond pump are good examples, because the water at this point was about to enter the pipe line to be pumped to the cooling pond. It was this pipe line that corroded most rapidly. It will be noticed that the corrosion of test-pieces was about one-half as great when the water was maintained alkaline to methyl orange and less than one-quarter as great when treated for dissolved oxygen maintained alkaline to methyl orange (see tests 1, 2 and 3 in Table II.)

EROSION CAUSED BY SUSPENDED COKE DUST

To determine the erosive action of the suspended coke dust in the cooling water, apparatus was made up in duplicate consisting of weighed short equal lengths of pipe of different sizes, connected together with reducer couplings, starting with the largest size and tapering to the smallest. One set of testing apparatus was arranged so that the largest nipple was connected to the service pipe carrying the cooling water from the decanter to the cooling pond and the smallest nipple was connected through a valve with a meter so that the rate of flow through the pipes could be regulated. The other piece of apparatus was arranged so that the small-

TABLE IV. RESULTS OF EROSION TEST WITH PRODUCER-GAS COOLING WATER

Direction of Flow Through Large Pipe Toward Smaller Pipe					
Pipe Size	Average Velocity Water During Test Ft./Sec.	Total Grams Lost	No. of Days in Line	Milligrams Lost per Sq. In. Exposed Surface	Milligrams Lost per 8 sq. In. per 24 Hr.
1x24 in.	16.5	25.650	13	690	53
1x24 in.	5.9	81.200	24	1,305	54
1x24 in.	3.7	61.100	24	775	32
1x24 in.	2.1	121.300	24	1,161	48
1x24 in.	1.6	108.5	24	892	37
2x24 in.	0.9	70.600	24	453	19
2x24 in.	0.7	75.700	24	406	17
Direction of Flow Through Small Pipe Toward Larger Pipe					
1x24 in.	19.4	27.600	13	740	57
1x24 in.	6.9	77.900	24	1,250	52
1x24 in.	4.3	72.000	24	910	36
1x24 in.	2.5	77.000	24	735	31
1x24 in.	1.9	69.200	24	569	23
2x24 in.	1.1	51.400	24	329	14
2x24 in.	0.6	65.600	24	353	15

est nipple was connected to the service pipe and the largest nipple to a valve and meter. The rate of flow through the largest nipple was regulated to be less and the rate through the smallest nipple was regulated to be considerably greater than the rate of flow through

the 6-in. service line between the decanter and the cooling pond. Water from the 6-in. service pipe was permitted to flow through the apparatus for 24 days. The apparatus then was dismantled, and the short pieces of pipe were reweighed and the weight lost per sq.in. of the exposed inner surface calculated. The results are presented in Table IV and plotted against water velocity in Fig. 5. Daily determinations of suspended matter

TABLE V. PROXIMATE ANALYSES OF SUSPENDED MATTER IN PRODUCER-GAS COOLING WATER WHEN USING RECIRCULATED FRESH WATER (PER CENT)

Source.....	Shoveled From Bottom of Inside Decanter	Shoveled From Outside Decanter	Filtered From Water Collected Near Intake to Pump
Volatile matter.....	7.71	2.13	51.2
Fixed carbon.....	59.01	76.76	
Ash.....	33.28	19.11	

in the cooling water made over a period of about two weeks showed a variation between 24 and 140 parts per million. Results of proximate analyses of samples of this suspended matter are shown in Table V.

CALCULATING LIFE OF 6-IN. PIPE

It is quite evident that erosion due to suspended coke dust and ashes plays a very important part in the deterioration of the cooling system.

Pitot tube readings indicated that the velocity of water in the 6-in. service pipe from the decanter to the cooling pond is approximately 12 ft. per second under average operating conditions. The erosion test showed this pipe to be wearing away at the rate of 55 mg. per sq.in. per 24 hours. From data presented in Table IV and from some measurements of standard 6-in. pipe, some interesting figures are presented below:

Thickness of standard 6-in. pipe = 0.3 cm. bottom of threads to inside surface.²

1 sq.in. of pipe, 0.3 cm. thick = 1.935 c.c. of iron and weighs 15,450 mg.

The life of 6-in. pipe eroding at the rate of 55 mg. per day is therefore $15,450 \div 55 = 281$ days, or 9 months and 11 days.

During the period of the erosion test the water in the decanter was maintained alkaline to methyl orange and freed from dissolved oxygen. Test-pieces of iron hung in the decanter where they were not subject to the erosive action of suspended coke dust lost weight at the rate of 3.6 mg. per sq.in. per 24 hours. At this rate of corrosion a standard 6-in. pipe will last for more than 10 years. This figure represents what might be expected with treated and filtered fresh water.

RECOMMENDATIONS AND SUGGESTED REMEDIES

Having determined the causes for the deterioration of piping and other equipment in the producer-gas cooling system, the following remedies were suggested:

(1) Cool and clean the producer gas with fresh water, and permit the water to waste to the bay after going through the cooling system. (2) Treat, cool and recirculate fresh water. The treatment recommended consists of filtration to remove suspended coke dust, neutralization of free mineral acid with lime, and removal of dissolved oxygen with steel turnings. (3) Cool and clean the gas with an excess of bay water and let it waste back to the bay. A brief discussion of each remedy follows.

Fresh water can probably be obtained most econom-

²Practically all the leaks in the cooling-water piping system developed near joints where threads cut in the pipe had made the iron thinner than the remainder of the pipe.

ically from wells. This water, freed of dissolved oxygen, if there is any present, by means of steel turnings, would cause the least corrosion of any of the remedies mentioned. Treated and recirculated fresh water would have its deleterious properties removed and would cause very little, if any, more corrosion than fresh water not circulated.

EXPERIMENTS WITH BAY WATER

The average of several analyses shows that bay water pumped from near the gas plant has about two-thirds as many dissolved solids as sea water and that the solids are similar in character to those in sea water. It is known that sea water is an active corrosive agent, particularly when hot. Accordingly, tests were made with special apparatus and under actual working conditions with bay water for cooling producer gas to determine the degree of its corrosive action under the conditions existing in the producer gas plant.

In test 4, Table II, are presented results of a test to determine the corrosive action of cold bay water before and after removing its dissolved oxygen. The water in this case had a temperature between 70 and 75 deg. F. It will be noticed that cold deactivated bay water had no appreciable corrosive action on iron. From this experiment the conclusion was drawn that the piping and cooling equipment handling cold bay water would not corrode very rapidly. There probably would be more corrosive action than this test indicated at points in the system where there is chance for galvanic action—e.g., where brass and iron are in contact. This action could be reduced by using iron valves and fittings in pipe lines. Table II also gives a very good comparison between the action of cold bay water and fresh water.

EFFECTS OF INCREASED TEMPERATURES

Sea water, in this case bay water, is more corrosive at higher temperatures than it is when cold. This property is due to the presence of calcium chloride and particularly magnesium salts. For example, magnesium chloride hydrolyzes to form hydrochloric acid and the latter readily reacts with iron. The extent of this reaction increases as the temperature rises. Because of this property of bay water, tests were made to determine its corrosive action in the presence of hot producer gas. These tests were made with raw bay water and with deactivated bay water—i.e., bay water from which the oxygen had been removed by passing through steel turnings. The results of these tests are presented in Table VI.

Comparing test 1, using raw bay water, with test 2, using deactivated bay water, it will be noticed that, in the presence of deactivated bay water, iron corrodes about three-fifths as rapidly as in the presence of raw bay water; also that, when using either raw or deactivated bay water, its corrosive action increases rapidly as the temperature rises. Test 3 was made at a higher temperature than test 2 and shows a correspondingly greater corrosive action. Test 4 with deactivated city water shows that, at a high temperature, there is some corrosive action in the presence of fresh water and producer gas. Tests 5 and 6 were made with weighed test-pieces of pipe resting on the bottom of a dustcatcher, which is probably the hottest part of the cooling system and where the most corrosion would take place when using salt water. These results agree closely with the results of tests 1 and 2. In the column "Calculated time to corrode through $\frac{1}{2}$ -in. stock of dustcatcher, etc.," are figures obtained by dividing the weight of a sq.in. of

iron $\frac{1}{4}$ in. thick by the average milligrams lost per sq. in. per 24 hours by test-pieces of pipe during each test, and converting this result to years and months. The figures in this column may be considered the life of the cooling system at its weakest point under varying con-

TABLE VI. CORROSION OF TEST-PIECES OF PIPE IN THE PRESENCE OF HOT PRODUCER GAS AND BAY WATER AND HOT PRODUCER GAS AND FRESH WATER

Test No.	Location of Test-Pieces	Days Duration of Test	Approximate Temp. of Test, Deg. F.	Kind of Water and Condition	No. of Test-Pieces of Iron Subject to Condition of Test	Av. Mg. Lost per Sq. In. per 24 Hr.	Calculated Time to Corrode Through $\frac{1}{4}$ -In. Stock of Dustcatcher, Etc.
1	In joint 6-in. pipe near No. 1 producer	14	130-160	Raw bay water	4	25	3 yr. 4 mo.
1	Ditto.....	14	100	Ditto.....	2	18	4 yr. 8 mo.
1	Ditto.....	14	70-80	Ditto.....	4	8	10 yr. 7 mo.
2	Ditto.....	14	130-160	Deactivated bay water	4	16	5 yr. 3 mo.
2	Ditto.....	14	100	Ditto.....	2	8	10 yr. 7 mo.
2	Ditto.....	14	70-80	Ditto.....	4	5	17 yr.
3	In nipple on top of dustcatcher No. 3	14	230-260	Ditto.....	7	30	2 yr. 10 mo.
4	Ditto.....	14	230-260	Deactivated city water	7	10	8 yr. 6 mo.
5	In bottom of dustcatcher No. 3	14	90-100	Raw bay water	6	22	3 yr. 10 mo.
6	In bottom of dustcatcher No. 3	14	110-120	Deactivated bay water recirculated from end of decanter	9	20	4 yr. 3 mo.

ditions when using bay water to cool producer gas. The farther away from the dustcatcher the gas travels the cooler it gets; therefore the life of the collecting main and condenser should be longer.

When 60 deg. F. or cooler water is available, the producer gas can be cooled sufficiently by pumping the cold water over the condenser and pumping warm water from the decanter over the dustcatchers and collecting main. To determine whether warm bay water causes greater corrosion under these conditions, weighed pieces of iron were suspended on the bottom of a dustcatcher and permitted to remain there for 14 days; then they were removed and reweighed. Water entered the dustcatcher at a temperature of 100 to 110 deg. F. and left at a temperature of 110 to 120 deg. F. The results are presented in test 6 of Table VI, and show that practically the same amount of corrosion takes place in the dustcatcher as when cold water which has not been deactivated is pumped. This recirculation, whether with bay water or fresh water, should not be practiced, because the water when tested contained 50 to 70 p.p.m. of suspended coke dust. Under these conditions, it is to be expected that pipes and pumps carrying the water from the decanter to the dustcatchers will erode rapidly. Bearing out this contention, several leaks developed while test 6 was in progress.

Because of the deleterious action that dissolved salts in bay water would have on the refractories if carried over with the producer gas when the latter is burned in the coke-oven battery, some tests were made to determine if the gas carried any of these salts while bay water was used for cooling.

The results of the tests showed that a small quantity of chloride was being carried over. Further tests indicated that this must have been due to hydrochloric acid, probably derived as a product of the hydrolysis of magnesium chloride at high temperatures.

When chlorides were found in the gas, the producers

were delivering gas at times at a temperature of 1,700 to 1,800 deg. F. Since that time numerous tests have been made when the producers were delivering gas under 1,400 deg. F., and only traces of chlorides were found in distilled water through which more than 100 cu.ft. of producer gas was passed. One sample through which gas had been passed was analyzed for magnesium, which is a common substance found in sea water, but only a trace was found. The conclusion reached after these tests is that no bay water salts are carried into the battery when bay water is used to cool producer gas.

COMPARING BAY WATER WITH RECIRCULATED FRESH WATER

Comparing tests made when using bay water for cooling producer gas and permitting the water, after passing through the system once, to waste to the bay, with tests made with unfiltered recirculated fresh water, it is obvious that the advantage lies with bay water. Tests show the life of the weakest points of the cooling system to be approximately nine months when recirculating unfiltered fresh water, compared with three to four years when using cold deactivated bay water. However, at best the use of bay water can be considered as being merely the lesser of two evils. Tests indicate that with an abundant supply of fresh water which can be allowed to waste to the bay after going through the cooling system once or with recirculated fresh water which has been treated and filtered, the life of the weakest point in the cooling system will be ten years or more. These figures must be qualified to the extent that they were calculated for a cooling system not deteriorated. There are probably places in the cooling system which are almost corroded through, due to having recirculated water containing suspended coke dust, and, no matter what change is made in the cooling water, these places will give way sooner than calculated above. In order to know which is the best of the three remedies discussed, it must be known which is the most economical.

CONSIDERATION OF COSTS

The most economical source of fresh water in sufficient quantities so that it can be wasted to the bay after going through the cooling system once is a series of wells drilled adjacent to the plant. The total cost of cooling the producer gas by this means will be the cost of drilling wells plus the cost of pumping through the cooling system.

To cool the gas with treated and filtered water, it will be necessary to install sand filters and lime-treating apparatus to handle approximately 2,000,000 gal. of water daily with the present cooling apparatus. This could be cut to 1,000,000 gal. per day with more efficient cooling apparatus. The total cost of cooling producer gas under these conditions will be the original cost of installing the treating and filtering apparatus plus their upkeep and operation, together with the cost of pumping to and from the cooling pond and the cost of city water to make up for evaporation losses.

The cost of using bay water will entail the expenses due to pumping the water plus the extra cost of upkeep in the cooling system, which will mean the renewal every three or four years of those parts of the cooling system that come in contact with the cooling water and the hot gases.

Manufacture of Pyroxylin Plastics

Properties of Celluloid—Methods of Mixing the Cellulose Nitrate With Camphor and Alcohol—Stabilizing—Filtering—Rolling—Baking—Sheeting—Polishing—Manufacture of Rods and Tubes—Scrap Utilization—Camphor Substitutes and Synthetic Camphor—Chemical Control

By J. R. DuPONT

WHEN cellulose nitrate prepared according to the methods outlined in a previous article¹ is mixed with camphor and denatured alcohol, plastic products result which are usually referred to as celluloid,² although it would be more correct to call them pyroxylin plastics. Sometimes for the sake of economy the camphor and alcohol are replaced partly or entirely by substitutes which will produce a more or less satisfactory celluloid.

Pure celluloid is a transparent substance having a density of about 1.35. It is a poor conductor of heat and electricity. The tensile strength varies from 6,000 to 10,000 lb. per square inch. It cannot be exploded by percussion or pressure. Exposed to a flame, it softens and takes fire rapidly, evolving very disagreeable fumes resulting from the volatilization of the camphor and also from the nitrous gases produced by the decomposition of the cellulose nitrate. Heated without compression, celluloid starts to decompose around 125 deg. C., the action being accelerated by increasing the temperature—around 165 deg. C. the decomposition is complete. If kept in hot water at about 85 deg. C., celluloid is softened enough to permit the molding of objects which will retain the shape of the mold after cooling.

Although almost insoluble in water, celluloid is soluble in acetic, propionic, nitric and sulphuric acids, the latter two causing decomposition. Strong alkalis also decompose celluloid, and this property is used in the recovery of camphor from unusable celluloid scrap.

Celluloid is slightly soluble in ethyl alcohol and is soluble in methyl alcohol; ethyl, methyl, butyl and amyl acetates; ethyl propionate, acetone; diacetone; triacetone; epichlorhydrin; dichlorhydrin; and alcohol solutions of camphor, acetanilide, methylacetanilide, chloral hydrate, tricresylphosphate, triphenylphosphate, tribenzylphosphate, etc.

MIXING THE CELLULOSE NITRATE AND CAMPHOR

Turning now to the manufacture of celluloid, the first operation consists in mixing the cellulose nitrate with camphor and alcohol so as to produce a gelatinized mass. The mixing may be done in boxes or by machine.

Mixing in Boxes.—When in slab form, the dry cellulose nitrate is first broken into small pieces in a specially constructed machine and then placed in heavy rectangular galvanized-iron boxes having sloping sides. Camphor alcohol solution or denatured alcohol is sprinkled on and mixed by hand with wooden paddles. These boxes are covered air tight and placed in a room where the temperature is kept around 30 deg. C. After

24 hours the mass is more or less gelatinized and ready to be rolled. This method requires from 50 to 60 per cent of alcohol when 35 per cent of camphor is used, and because of the high percentage of alcohol used and the time required, nearly every factory has abandoned this process for the following one:

Mixing by Machine.—The cellulose nitrate is dumped into a kneading machine in which two specially shaped steel blades turn in opposite directions, assuring a constant and thorough mixing of the cellulose nitrate with the camphor and alcohol. Camphor (if not previously mixed with the cellulose nitrate) is added and also the denatured alcohol, and the machine is kept in motion for about 1 hour. After this time the mass is completely mixed, but not converted, and at this stage is placed in galvanized-iron boxes which are transferred to a warm room, where they stay long enough to permit partial conversion of the cellulose nitrate.

A far better and quicker way to produce the gelatinization of the cellulose nitrate is to use a jacketed kneading machine which will permit heating of the cellulose nitrate, camphor and alcohol and produce a complete conversion in about 1 hour's time. The heating is done with hot water and complete control of the temperature is necessary. Generally it is not permitted to go above 60 deg. C. This method of mixing reduces not only the time of the operation but also the quantity of denatured alcohol required to obtain a good conversion and with a good grade of cellulose nitrate only 40 per cent of alcohol is necessary. As the conversion is complete, the subsequent operation of rolling is shortened.

Some factories prefer to use more alcohol for the conversion, say 55 to 65 per cent of the weight of the cellulose nitrate, and after the conversion has been effected, reduce the alcohol contents to about 30 per cent, using vacuum as means of recovery. To obtain this recovery the mass is first heated to around 60 deg. C. and as soon as the conversion is obtained the mixing box is connected with the vacuum pump. By raising the temperature the alcohol vapors are removed by the pump and after being cooled are collected in a tank. We think that it is better to use around 45 per cent of denatured alcohol for the conversion, because the recovery of an excess of solvent requires longer heating which may result in discoloration of the paste.

In any of the methods used, the temperature of the kneading machine has to be always the same, as a difference in the heating temperature will give a variation in color—particularly in the manufacture of transparent and ivory—which is termed "off-color."

When cellulose nitrate containing alcohol is used, the gelatinization can be accomplished more quickly and more completely than when dry cellulose nitrate is employed; also, and of great importance, the chances of accidents during the mixing are reduced to a minimum.

¹The author reserves the right of publication and translation of this article.

²"Manufacture of Cellulose Nitrate for Pyroxylin Plastics," CHEM. & MET. ENG., vol. 26, No. 1, p. 11, Jan. 4, 1922.

³Although celluloid is a trade name, it has become rather firmly established in the literature as a designation for pyroxylin plastics, and this usage has been followed in this article.

Often in using dry cellulose nitrate in slab form, the slabs are not broken in small pieces before mixing, and the excess pull necessary to start the machine may develop sufficient heat to ignite the cellulose nitrate dust and thus cause the explosions which occur from time to time, often with fatal results. By using the proper kind of kneading machines and breaking up the slabs the mixing of dry cellulose slabs is safe. The percentage of moisture in the cellulose nitrate affects the results of the conversion and when above 5 per cent, poor results can be expected. The quantity of alcohol necessary for good conversion of the cellulose nitrate varies with the solubility and viscosity, but at least 40 per cent of denatured alcohol is necessary.

STABILIZING

Celluloid made with a good grade of cellulose nitrate will keep its original color and structure for years, but as a preventive measure every manufacturer stabilizes his celluloid. The stabilizing agent will check any gradual development of acidity and for this reason is generally called an antacid. For white and ivory colors no antacids are used, as the pigment added to the cellulose nitrate, which is usually zinc oxide, will act as stabilizer. But for transparent, shell and other translucent stock, antacids must be used. These must be soluble in alcohol, impart no cloudiness to the finished celluloid, and reduce to a minimum the discoloration due to exposure to light. Many different antacids have been recommended, but the most used are urea, calcium lactate and zinc acetate for transparent celluloid, magnesium oxide and magnesium carbonate for the translucent or opaque stocks.

So as to obtain a perfect mixing of the antacid with the cellulose nitrate, which is essential, the addition of the former is generally made during the kneading operation. The quantity employed varies from 1 to 2 per cent of the weight of the cellulose nitrate. The study of antacids is very important, especially for transparent stock, since by selecting the proper one it is possible to obtain a transparent which will keep its original color instead of shortly becoming discolored, as is the case with many of the celluloid curtains used on automobiles.

FILTERING

In spite of all precautions taken during nitration, washing and drying, it is very difficult to obtain a cellulose nitrate which will be absolutely clean and which will produce a first class celluloid. To remove these impurities or specks from the cellulose nitrate paste, it must be filtered. Two different kinds of machinery are used for this purpose. The first is a hydraulic press of the same type as used in the manufacture of celluloid tubes, but of larger capacity. The celluloid paste is heated around 65 deg. C. and pushed through a metallic or camel's-hair screen under a pressure of 3,000 to 3,500 lb. per square inch.

The other method consists in using a mechanical screw filter (Fig. 1) which is composed of a jacketed semi-steel cylinder 40 x 12 in. having two separate jackets so as to regulate the temperature of the cylinder. In the cylinder is a revolving steel worm of varying pitch which can also be heated by means of hot water circulation. The head of the machine, made of cast steel, is also jacketed and supports a steel perforated plate 2½ in. thick, on the front of which is placed the material used to filter the celluloid paste, which generally consists of a very fine mesh screen made of bronze wire or special filtering cloth (felt cloth, camel's hair, etc.).

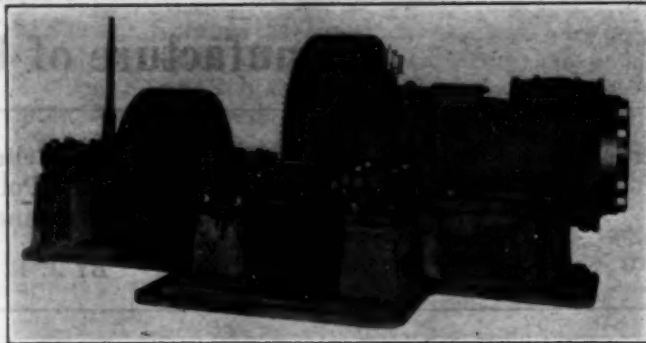


FIG. 1. STRAINER FOR FILTERING CELLULOID PASTE

The speed of the worm is about 9 r.p.m. and 100 hp. is required to run the machine. Generally an electric motor is used as motive power, and in this case the motor is placed below the floor line on account of the fire hazard. The stock to be filtered is fed into a pocket measuring 10 x 9 in. The front of the cylinder, the head and the worm are heated, but the back jacket is kept cool to prevent the stock from working back in the feeding pocket. The temperature is kept around 60 deg. C. by hot water circulation, and a recording thermometer permits the operator to control the heating at all times.

The productive capacity of the straining machine varies very much with viscosity and the alcohol content of the paste to be filtered, the kind of the filtering medium and also with the quantity of impurities to be removed, but generally an average of 400 to 500 lb. of celluloid paste can be filtered per hour. After burning off the impurities metal screens may be used again. In the case of scrap to be worked over, after mixing, it is submitted to a slight rolling before filtration.

ROLLING

After mixing, the celluloid paste obtained contains more or less unconverted cellulose nitrate. To obtain a homogeneous paste, the mixed cellulose nitrate is rolled, using two horizontal hollow cylinders made of chilled steel, supported by a heavy frame and turning in opposite directions at about 13 r.p.m. The back cylinder is stationary, but the front roll can be moved, the space between the two rolls being regulated by two screws. Guards prevent the paste from working over the ends of the rolls. Iron pipes going inside the cylinders permit the heating or the cooling of the paste, this being done by steam and cold water. A specially constructed clutch controls the machine, and a safety device is provided for stopping the rotation of the cylinders in an emergency. Above the rolls a hood is generally installed and connected by large galvanized-iron pipes with a fan which carries the alcohol vapors outside of the building, where they are generally lost. The first rolls used were of small diameter varying from 10 to 12 in., but today practically every factory uses rolls of larger diameter—that is, from 18 to 22 in., for a length of 48 to 60 in. Fig. 2 shows a 22 x 60-in. mill with coil clutch.

The rolling process is as follows: The rolls are first heated at different temperatures, the front one, which carries the paste, having a temperature around 55 deg. C. The back roll is heated less, for if too hot the stock will leave the front roll and stick to the back one. The celluloid paste is then dumped on the rolls and the screws regulating the space between the rolls is opened so as to obtain a sheet about ¼ in. thick. At this

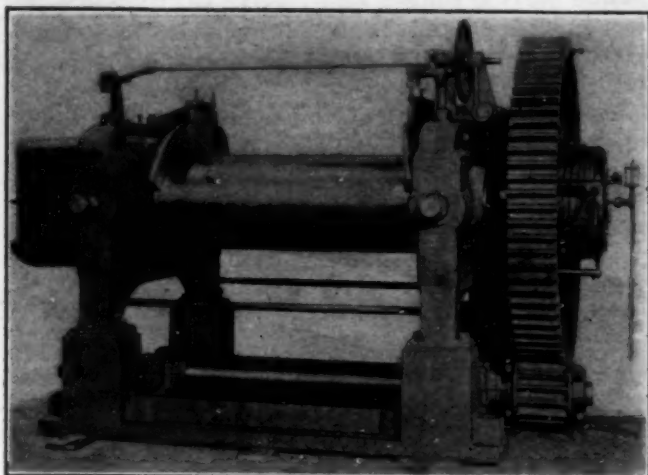


FIG. 2. CELLULOID MILL

stage the dye solutions or pigments are added to the paste according to the color desired. From time to time, the rollman cuts the sheet on the roll with a short knife so as to assure the complete homogeneity of the paste. If the paste is in a bad state of conversion, the screws controlling the front roll are tightened so as to obtain the minimum space between the rolls and thus produce a very thin sheet, which assures the crushing of the non-converted parts. When the operation is judged complete—that is, when the blending is as perfect as possible and the paste has attained the right proportion of solvent to permit pressing—the paste is taken off of the roll and passed again so as to obtain smooth sheets of stock, which are placed on a table of which the top has the dimensions of the plate of the block baking press. When all the paste has been thus sheeted, the sheets are trimmed to the exact size and are ready to be pressed.

The rolls are generally electrically driven and two to eight rolls can be placed on the same shaft. Even with an electric motor of the low-speed type a reducing gear has to be used to obtain the very low speed at which the rolls turn (13 r.p.m.). As to the power required, this varies from 10 to 12 hp. for 12-in. rolls up to 25 to 30 hp. for rolls of 18 to 22 in. diameter. The quantity of paste that can be rolled per hour varies much not only with the quality of the cellulose nitrate and the solvent content, but also with the kind of celluloid to be made. Generally two rolls are working on the same block and they are attended by four men, two rollmen with two helpers. Taking an average

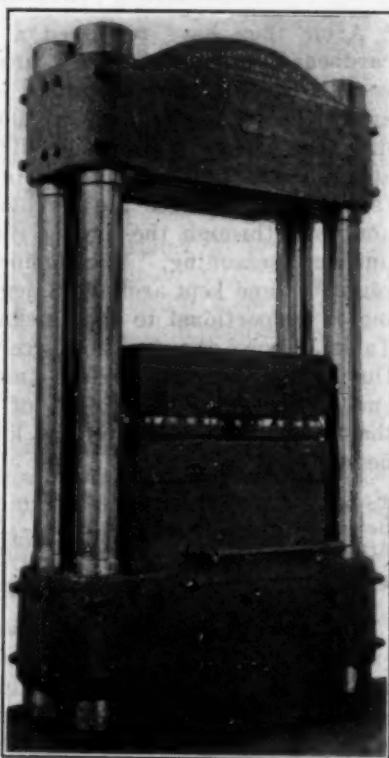


FIG. 3. CELLULOID PRESS

of 300 lb. of wet paste to make a finished block, this means that each roll will have to work 150 lb. of paste, which will require from 1½ to 2½ hours.

The loss of solvent during the rolling is variable, but as an average 17 to 20 per cent is lost during the operation, the paste going to the baking press containing 16 to 18 per cent of alcohol. The recovery of alcohol lost during rolling has been tried from time to time, but to the author's knowledge no factory has a permanent working installation.

BAKING

After rolling comes the baking operation, which when rightly conducted will give a celluloid block absolutely homogeneous. To obtain this result the rolled celluloid is placed in a hydraulic press, where it is heated under pressure so as to obtain a plastic mass. At this stage the mass is cooled under a greater pressure, which operation will expel the air bubbles disseminated in the mass and also completely weld the sheets.

The presses used are composed of a heavy cast-iron

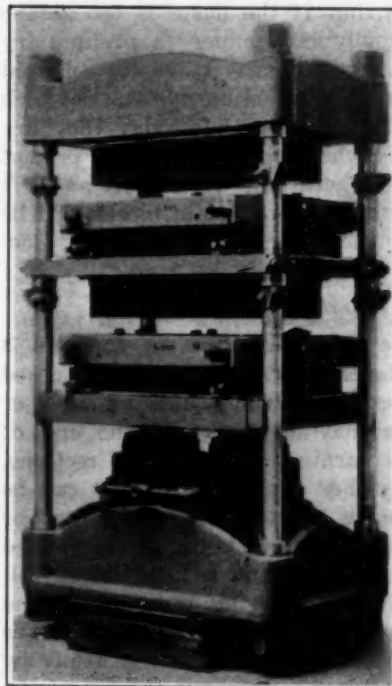


FIG. 4. DOUBLE DECK CAKE PRESS

bottom yoke, generally cast integral with the cylinder, supporting a plate on which a specially constructed rectangular bender receives the rolled celluloid sheets. Situated above the bender is a rectangular plunger which fits the bender and presses down the celluloid. The plate, the bender and the top plunger are hollow and can be heated by steam or hot water and cooled by water circulation. The rolled celluloid sheets are placed in the press on a semi-steel plate which has the dimensions of the bender and

the surface of which has been grooved diagonally, thus permitting the block pressed to be fastened securely to the plate and stand the pulling which occurs during the sheeting.

In the early stage of manufacture the baking presses were made with only one deck and thus only one block was baked per operation. In order to reduce the labor, presses were made with two rams working in opposite directions so as to lift the plunger placed above the bender; by operating the lower ram the block was thus taken off the bender. This type of press is quite extensively used abroad. To obtain a greater production, the next step was the construction of presses with two decks, which would permit the baking of two blocks in the same press. Today most of the presses are made with four benders in which four blocks are baked in one operation. The dimensions of the benders are generally 55 x 23 x 6 in., the dimensions of the pressed block being about the same. Fig. 3 shows a 25 x 58-in. press and Fig. 4 a 23 x 44-in. double deck cake press.

The pressure used during the baking is generally 500 lb. per square inch; during the cooling the pressure is increased up to 3,000 to 3,500 lb. per square inch. The temperature at which the press is heated varies with the duration of the heating, but in no case is this temperature carried above 90 deg. C. On the average, from 4 to 5 hours at 85 deg. C. is required to bake a celluloid block weighing about 300 lb., and the same time for the cooling.

Originally the heating was done with live steam, which gave a very irregular operation, but today hot water is used almost exclusively. The water may be heated in a tank provided with a steam coil, and forced through the press by a centrifugal pump. Placed on the steam line is a regulator which stops the flow of the steam when the correct temperature of the water is reached, the temperature being registered by a recording thermometer.

PRELIMINARY SEASONING OF BLOCKS

After pressing, the celluloid if properly rolled is ready for the sheeting, but if the paste is too soft—and this occurs principally in summer—a preliminary seasoning is necessary. In the early stages of celluloid manufacture the blocks were cooled by cold water which was run on the top of the blocks, but today they are placed in cooling rooms where the temperature is kept around 12 deg. C. by refrigeration. If too soft and left in too warm an atmosphere, the celluloid blocks will be full of pin-holes due to the expansion produced by alcohol vapors.

SHEETING

The sheeting of the celluloid blocks is done on a specially constructed planer (Fig. 5), which is composed of a heavy frame or bed supporting a moving table or platen controlled by a driving screw, on the end of which are two pulleys turning in opposite directions. By means of a clutch either one of the pulleys can be shifted on and thus make the table move forward or backward. On the front of the bed is a knife supported by a frame connected by screws and gears to a controlling shaft which permits the lowering or raising of the knife. The plate supporting the celluloid block to be sheeted is placed upon the table and secured firmly by bolts; the knife is lowered so as to shave the top of the block and obtain a perfectly horizontal surface; then the knife is lowered to obtain the desired thickness, adding to this the known thickness which will be lost during the subsequent seasoning. This allowance varies directly with the final thickness desired. To obtain a sheet 0.010 in. thick the stock is sheeted 0.012 in.; for 0.100 the gage will be 0.113; for 0.200, 0.240, etc. The sheeting machine is generally driven by a 10-hp. electric motor, but 5 hp. is sufficient.

Recently there has been introduced a hydraulic sheeter which is constructed in a similar way to the mechanical one, except that the platen is propelled by a hydraulic ram. The advantages claimed are that this machine permits greater production and a more accurate sheeting, particularly when cutting thin sheets. Also the chances of having the sheets soiled with oil are less. Only a few factories have installed this new sheeter on trial and it is doubtful whether this machine will replace the old type of sheeter, which when rightly handled is very efficient and the cost of which is far less.

As soon as the sheets are cut they are marked so as to know the color, block number, thickness and date of

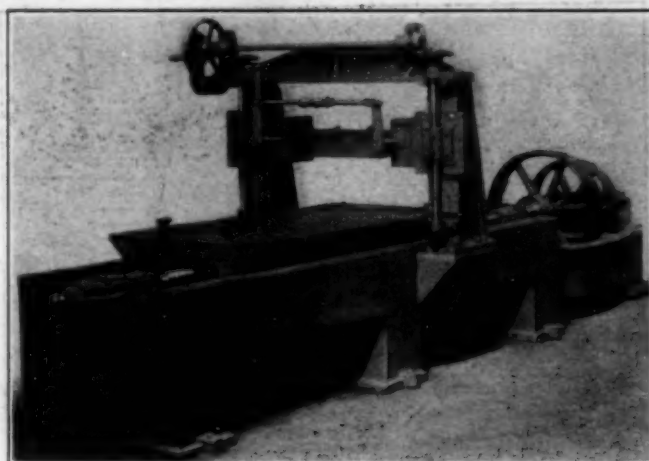


FIG. 5. PLANER FOR SHEETING CELLULOID BLOCKS

sheeting and are placed between special cardboard sheets, where they stay a certain time according to the thickness. During this period a certain amount of solvent is absorbed by the cardboard so that when taken out to be submitted to the real seasoning the sheets will not warp badly and will not necessitate a preliminary pressing before polishing. The cardboard after having been used for a certain time is submitted to a drying operation so as to remove the solvent absorbed. During the sheeting a certain quantity of scrap is made varying with the skill of the operator and also with the constancy and the thickness of the sheeted celluloid. Also a certain amount of imperfect sheets are made. The following shows a good average:

	Per Cent		Per Cent
Imperfect sheets...	7 to 9	Scrap.....	6 to 7
Perfect sheets.....	82 to 84	Loss by evaporation...	2 to 3

The imperfect sheets are sold as seconds and the scrap is sent to the mixing room, where it is worked again.

SEASONING CELLULOID SHEETS

After they have remained a certain time between cardboard, the sheets are transported to the drying room, where they are submitted to a final drying. Generally the drying is done by hot air circulation. At first the sheets were hung directly above protected steam-heated pipes, but today in most of the plants a fan is used to force the air over a steam-heated coil and then through the drying room, thus giving more uniform seasoning. The temperature of heating is regulated and kept around 38 deg. C. The time of drying is proportional to the thickness of the sheets and Table I shows the duration according to the thickness. During the drying a certain amount of solvent is lost and consequently the weight of the stock is reduced; the following table shows the loss for different thicknesses:

Gage, In.	0.085	0.060	0.090	0.040	0.100	0.085
Before drying, lb. . .	261	311	284	304	214	245
After drying, lb. . . .	226	263	241	258	179	207
Loss, lb.	35	48	43	46	35	38
Loss, per cent.	13.4	15.4	15.1	15.1	16.3	15.5

The process referred to as "water drying," which is extensively used to dry smokeless powder, finds little application in the drying of celluloid. When used, the celluloid sheets are placed vertically in tanks where water at a temperature of about 45 deg. C. is kept in motion, the "drying" being done by the absorption of

the solvent by the water. This method is much quicker than that of using hot air, but at the end of the process the stock has to be heated so as to remove the water retained by the stock. Vacuum drying if properly conducted is efficient but requires an expensive installation.

During the drying of the sheets about 14 to 15 per cent of alcohol is lost, the recovery of which would represent a large saving, but so far little has been done to avoid this loss, largely because the changes which

TABLE I. TIME OF DRYING CELLULOID SHEETS

Thickness, In.	Time of Drying	
	Between Cardboard, Days	In Drying Room, Days
0.004 to 0.009	1	2 to 3
0.010 to 0.020	1	4 to 8
0.021 to 0.040	1	8 to 16
0.041 to 0.080	2	16 to 24
0.081 to 0.120	3	24 to 34
0.120 to 0.160	4	34 to 50
0.160 to 0.180	5	50 to 58
0.180 to 0.200	6	58 to 64

would have to be made in the present installations and the extra machinery required seem expensive. However, it is reasonably certain that in the case of a factory producing about 3,000,000 lb. of celluloid per year the installation of a system of solvent recovery, for the rolls and drying rooms, will prove a good investment.

POLISHING

After the celluloid sheets have been dried they have warped more or less and have to be straightened. As the celluloid sheets are generally sold to the trade polished, the two operations of straightening and polishing are carried out in the same hydraulic press. The press used is of very heavy construction and generally has two rams above which are twelve semi-steel plates which are supported so as to leave an opening of about 2½ in. between the plates. Each plate is cored and connected to the main pipes distributing steam and water. The dimensions of the plates are generally 56 x 25 in. and the maximum gage pressure used during the polishing is 3,500 lb. per square inch.

The polishing is done by heating under pressure the sheets placed between polished plates; after cooling the surface of the sheets will have a perfectly polished surface.

The polishing plates used have to be of first quality, and it seems that the best are made in Germany. During the World War every factory experienced great difficulty in getting a supply of good polishing plates. These plates are generally made of a steel sheet on each side of which a layer of nickel is rolled while the metal is hot. The rolling process is kept on until the metals are cold; then the plates are submitted to a special polishing process which will give a perfect finished surface. Different alloy compositions have been tried from time to time, but only pure nickel keeps this surface perfect for a long period and after the plates have shown wear marks they can be refinished.

The polishing operation is as follows: The cleaned celluloid sheets are placed between nickel polishing plates and two to eight sheets are then piled up, the number varying with the thickness of the celluloid sheets and the opening between two press plates. This is called a set; each set is placed between heavy pads of cotton sheets which are supported by steel sheets. The press, which has been heated during the laying operation to around 85 deg. C., is then filled and low pressure—that is, about 500 lb. per square inch—is applied during the heating period, which lasts from 1½ to 5 minutes, ac-

cording to the thickness of the celluloid sheets to be polished. Then cold water is sent through the press, the pressure being kept around 3,000 to 3,500 lb. After the cooling operation, which takes from 15 to 45 minutes, the pressure is shut off and the sheets are taken out. In Europe the polishing presses are of the same construction but stronger so as to resist pressures up to 6,000 lb. per square inch.

After polishing, the celluloid sheets are trimmed to 50 x 21 in. generally and are then stored in unheated rooms until they are sold and shipped away.

MANUFACTURE OF RODS AND TUBES

Celluloid rods can be made by two ways—by cutting or by stuffing. Generally the cutting method is used for shell and mottled designs, the stuffing process being used for uniformly colored rods. The cutting of the rods is done with the sheeting machine employed to cut sheets, the knife being replaced by a cross-feed screw supporting a tool head in which are inserted special steel cutters placed at different heights and on the side of which are small individual angle knives which edge the stock left after the rods have been cut. This method of cutting rods gives the best of results, the only disadvantage being the great quantity of scrap produced, this varying, with the gage of the rods cut, from 40 to 50 per cent. The loss of solvent during the operation reaches 5 to 8 per cent, and the solvent left in the rods after cutting varies from 8 to 10 per cent. Another method for cutting rods is to use special cylindrical presses in which the celluloid paste is pressed on a steel axle which is placed in the center. After cooling, the block is transferred to a specially constructed lathe on the front of which a cutter moves, thus cutting an endless rod.

The stuffing of rods is done on specially constructed hydraulic presses which are composed of a cylindrical cast-iron chamber which can be heated or cooled. (See Fig. 6.) In this chamber is placed the specially rolled paste, which is pushed through a die by a hydraulic ram working at a pressure varying from 500 to 3,000 lb. per square inch. The heating and pressure, combined with the density of the paste, are the factors regulating

the production of a perfect rod. The heating has to be perfectly controlled around 75 deg. C., as above this temperature decomposition of the celluloid paste can take place and frequently disastrous accidents are reported which are generally due to the carelessness of the operator. In some factories the hydraulic stuffers are replaced by mechanical ones which are of the same construction as the mechanical straining machine described before, but the cylinders are smaller, being generally from 4 to 6 in. in diameter. These mechanical stuffers require 10-hp. motors and are as efficient as the hydraulic ones, although the density of the paste to be stuffed has to be varied.



FIG. 6. EXTRUDING PRESS FOR RODS AND TUBES

The two machines just described can also be used for making tubes, and in this case a special die having a pin in the center is used. As to the production, this varies with the dimensions of the rods and tubes to be made and also with the capacity of the cylinder. As an indication, from 7 to 9 lb. of 0.100-in. gage rods or tubes can be made per hour using a machine having a cylinder diameter of 4 in.

SCRAP UTILIZATION

All scrap made in the factory, together with that coming from the manufacturers of novelties, is made into celluloid. The scrap coming directly from the factory is sorted by colors and thicknesses, and mixed as soon as possible. Dry scrap has to be washed and submitted to a cleaning and sorting process before mixing.

The scrap can be mixed in boxes similar to those described for the mixing of cellulose nitrate. Generally 3 to 5 per cent of camphor and 20 to 35 per cent of denatured alcohol is required according to the scrap used. After standing for a period varying from 3 to 6 days the scrap paste is cut and, after a slight rolling, is filtered. This scrap paste can be used alone, but it is generally mixed in different proportions with cellulose nitrate paste to make a celluloid block.

So as to reduce the quantity of alcohol and the time of mixing, most of the celluloid plants use large specially constructed tumblers in which the scrap and camphor alcohol solution are kept in motion for about 1 hour. This method reduces the time of the operation.

CAMPBOR SUBSTITUTES AND SYNTHETIC CAMPBOR

True celluloid is made with natural camphor which has been refined. Sometimes, when camphor prices are too high, as was the case during the war, substitutes have to be used. The number of substitutes which can be used is limited. Acetanilide, methylacetanilide, tri-cresylphosphate, triphenylphosphate, triacetine, etc., have all been tried. Acetanilide is a poor solvent for cellulose nitrate and above 10 per cent in mixtures with camphor gives a brittle celluloid which changes color with time. Methylacetanilide, having a very low melting point, produces a celluloid which is entirely too soft and discolours quickly. Generally the same can be said of the other substitutes; but nevertheless during the war great quantities of triphenylphosphate were used and some absolutely camphorless celluloid of excellent quality was manufactured which has kept perfectly up to this time. To obtain this celluloid specially purified triphenylphosphate was employed in connection with a specially prepared cellulose nitrate. By modifying the manufacturing process a little very good results were obtained, and the only contradictory fact observed was that the celluloid produced was harder than celluloid made with camphor, but this was probably due to the grade of cellulose nitrate used.

With the drop in price of Japanese camphor, the use of these substitutes (which are generally higher than camphor in price), has been discontinued, much to the satisfaction of manufacturers using outside celluloid scrap, as a great quantity of celluloid made with technically pure triphenylphosphate has given trouble on account of discoloration.

The subject of synthetic camphor requires only brief consideration. When properly prepared, synthetic camphor is practically identical with the natural product. Its manufacture is not a recent development, however.

As far back as the Russo-Japanese war, when camphor was unobtainable in Europe, the writer was using synthetic camphor made by the Ampere Company working the Thurlow process, with very good results. Abroad, the manufacture of synthetic camphor has become active again due to the high price of camphor there. The resumption of the domestic industry depends upon several factors: The tariff; the price of camphor maintained by the monopoly; the price of turpentine. At this writing synthetic camphor of very good quality from abroad sells at the present price of Japanese refined camphor.

CHEMICAL CONTROL

The chemical control of a celluloid factory is quite a large undertaking, for if each step of the process is not regulated trouble will arise. Not only must the nitration, acid recovery, washing and bleaching operation be controlled very carefully, but the solvent, camphor and camphor substitutes, dyes and pigments must also be tested. In spite of this, almost every day the laboratory will receive some sample of stock which has given trouble during manufacture. Furthermore, there is always research work to be done on methods for improving the finished celluloid. In fact, every day something new has to be learned and the chemist is responsible in large measure for the success or failure of the manufacturing processes.

The writer desires to express his indebtedness to the following firms for the illustrations of celluloid machinery: Farrel Foundry & Machine Co. and the Allen Machine Co.

Corrosion of Underground Pipes*

In certain sections a very serious condition exists in connection with underground pipe systems, owing to the corrosive action of the soil upon the iron of which the pipe is made. The loss from this cause is so large that the Bureau of Standards has recently undertaken an extensive investigation of the subject with particular reference to the corrosive action of soils on gas and water mains.

In this investigation the bureau has the co-operation of the Bureau of Soils of the Department of Agriculture, the pipe manufacturers and the public utility companies through the research sub-committee of the American Committee on Electrolysis. Forty locations have been selected representing the different kinds of soils to be found throughout the United States, and at each locality a number of samples of every kind of iron and steel pipe in commercial use will be buried. Some of these samples will be uncovered from time to time to determine the rate of corrosion. Complete data on the physical and chemical properties of the soil and the pipes will be obtained and extensive laboratory experiments will be conducted to determine the effects of variations and individual characteristics of both soils and pipe materials. Some tests of representative pipe coatings will also be undertaken.

The results of the tests should be of great value in determining the importance of soil corrosion and in selecting the kind of pipe best suited for use in any particular soil. It is expected that considerable data as to the relative rates of corrosion of the different kinds of pipe in the soils under observation will be obtained within 2 or 3 years, but the investigation will probably continue over a period of 8 or 10 years.

*From Technical News Bulletin 55, Bureau of Standards, Nov. 9, 1921.

The Manufacture of Chromium Ball-Bearing Steel in the Heroult Furnace

A Description of Melting and Processing of Electric Ball-Bearing Steel, With a View of the Most Serious Defects in This Class of Material—Recommended Practice for the Elimination and Control of These Defects

By F. T. SISCO
Metallurgist

THE manufacture of electric high-carbon chromium ball-bearing steel in 6- to 8-ton lots has until recently been accompanied by the difficulty of producing a product which is free from surface seams and internal hair lines. The former defect, while serious, may be eliminated by proper treatment during melting and processing. The latter, which seems to be an oxidation defect not got rid of in melting, persists through all further working of the steel and appears finally as a failure in the hardened ball or race.

Previous to 1914 the finest carbon chromium ball and ball race steel was imported from Germany in the form of billets; completed manufacture was in this country. One large firm, at least, manufacturing ball bearings and ball races owes its reputation to this German steel. Excellent ball steel has been made by the crucible process, some being produced by this method of manufacture to this day. However, the manufacture of good ball steel in common with other alloy steels should be the feature of the electric furnace, which theoretically should produce a perfect ball steel from a cheap base material. This statement should not be construed to mean that no good ball steel is as yet made in the electric furnace. There are many manufacturers that are producing an excellent steel for this purpose, but the fact is they are not doing it consistently. Even those plants making a specialty of this grade of steel occasionally tap heats of which 20 per cent, 50 per cent or even all must be relegated to the scrap pile.

It is the object of the author to describe in the lines that follow the practice developed at an electric steel plant, a practice that was the result of four years' study of this steel and by which a more uniform and better product was obtained.

The three defects that seem to be especially common and prominent in carbon chromium steels are segregation, surface defects and internal defects. The first two are more or less under the control of the melting, rolling, chipping and inspection departments. The third presents a difficulty unique in that it is apparently caused by the raw materials charged into the furnace and not subsequently eliminated.

Carbon chromium steel for ball bearings and ball races is made of only one grade of material, the carbon ranging from 0.90 to 1.20 per cent, the manganese 0.20 to 0.50 per cent, the chromium 1.10 to 1.75 per cent. Silicon is generally under 0.30 per cent and phosphorus and sulphur low. The most common analysis for this steel is carbon 1.00 to 1.15 per cent, manganese 0.25 to 0.45 per cent, chromium 1.35 to 1.65 per cent, silicon 0.15 to 0.25 per cent and phosphorus and sulphur below 0.025 per cent. The steel owes its properties to the presence of double carbides of iron and chromium, which

confer great hardness on the metal, a hardness which is not accompanied by as much brittleness as the hardness of carbon alone. On the behavior of these carbides depends the successful annealing and subsequent hardening of the steel. When properly hardened the steel is martensitic probably with a little troostite present, especially if slightly drawn, and in breaking presents a fracture that is very close grained and silky, not unlike the fracture of hardened high-speed steel.

MELTING

The best melting practice¹ for the manufacture of this steel is melting with partial oxidation. Theoretically, in the Heroult furnace complete deoxidation is possible no matter how badly the molten bath is contaminated with oxides and gases. Practically, however, due principally to insufficient knowledge of the fundamental principles of deoxidation, and especially since the molten bath must be very thoroughly deoxidized to make good ball steel, melting down to avoid oxidation as much as possible is preferable.

The scrap used should be selected, free from excessive rust and scale and not exceeding 0.05 per cent sulphur and phosphorus. A mixture of ball steel crop ends, open-hearth scrap such as billet and bloom crops, boiler plate, etc., makes an excellent base. For a 15,000-lb. heat 600 to 800 lb. of limestone is charged on the bottom of the furnace, followed by the scrap. It is sometimes advisable, when considerable low-carbon scrap is charged, to introduce a few hundred pounds of low-phosphorus pig iron down toward the bottom of the charge. Care should be used to avoid too high a temperature during melting, as the selective oxidation of the phosphorus depends almost wholly on this factor. There will always be sufficient oxygen present in the scrap to permit the easy and complete elimination of all of this element. The cold charge may be melted down with high power until a fair-sized pool of molten metal is present around the electrodes. Complete melting of the charge is then hastened, and the temperature kept low, by pushing into the pool, by means of iron bars, the partly melted sticky mass of scrap clinging to the sides of the furnace.

When the charge is completely melted, a test sample is taken out and sent to the laboratory for immediate analysis of carbon, phosphorus, manganese and chromium. In case much chromium scrap was used in the charge, the slag may be viscous, especially if the chromium oxide, Cr_2O_3 , is near 10 per cent. This slag can be thinned sufficiently by the addition of a little fluorspar.

¹Many points in connection with the melting practice has been discussed in a previous article entitled "Deoxidation and Desulphurization in the Heroult Furnace," appearing in *CHEM. & MET. ENG.*, vol. 26, No. 1, p. 17, Jan. 4, 1922.

In about 10 minutes the phosphorus result is reported, and if within specified limits the furnace is tilted slightly and the oxidizing slag removed by hand rabling. The final portion of slag near the banks is easily removed by throwing a few shovelful of lime on the metal and poling the now thick mass to the front by means of long green saplings introduced through each side door.

If the scrap was selected properly and if melting conditions were correct, the bath when melted will contain 0.50 to 0.75 per cent carbon, about 0.20 per cent manganese, chromium varying from a trace to 0.75 per cent, depending upon the amount of chromium scrap used, sulphur between 0.02 and 0.04 per cent and silicon and phosphorus below 0.025 per cent. The white slag is then immediately applied as described below. The presence of considerable carbon, some of the manganese and more than half of the chromium insures a metal in which oxides and dissolved gases cannot be present in large amounts.

When sufficient chromium scrap from the plant rolling mills and inspection sheds is available for a whole heat, the melting may be carried out quickly without oxidation. This method insures a more thoroughly sound and deoxidized steel than any other form of melting practice, but can be used only when scrap containing phosphorus well below the required percentage in the finished steel is used.

This rapid method consists essentially of melting a charge made up completely of ball steel scrap, and commencing the building up of the white slag as soon as there is molten metal present in the furnace. When this practice is used, the composition of the steel after melting will be carbon 0.85 to 1.00 per cent, manganese 0.20 to 40 per cent, chromium 1.10 to 1.30 per cent, silicon about 0.05 per cent and sulphur and phosphorus low. The phosphorus will be the same as or very slightly higher than the percentage in the scrap, as none is lost in melting. Even though this melting under a white slag produces quicker heats, more satisfactorily deoxidized heats in many cases, as well as a steel to which no alloy additions except a little ferrochromium need be made, however as a daily practice it is impractical on account of the scarcity of suitable scrap. It is often possible when melting and working large tonnages of chromium steel to collect enough plant scrap so that a series of white slag heats may be made, but due to the fact that chromium steel scrap, and other scrap for that matter, containing less than 0.02 per cent phosphorus is never available in large tonnages, the partial oxidation process above described is preferable. In no case should a complete oxidation in melting be tolerated for this grade of steel. This practice, so common in electric steel plants, consists essentially in melting down almost any kind of scrap with limestone and iron ore or roll scale, so that all of the carbon, silicon, phosphorus, manganese and chromium, if present, is oxidized and removed from the metal. This practice when applied to chromium steels produces almost without exception a low-grade product. High-carbon, high-chromium steel is perhaps one of the most sensitive of the alloy steels made in the Heroult furnace, and one of the most difficult to deoxidize completely.

In the case of most other steels it is not difficult to remove excessive oxide and gas contamination caused by melting with iron ore or roll scale; with chromium steel, however, as most of the trouble occurs between the time of the ferro-alloy addition and the pouring of

the ingots, it is highly desirable to have a steel almost 100 per cent deoxidized before making the ferro-alloy addition.

Why it happens in many cases that a charge of ordinary scrap melted low in carbon, recarburized on the bath, apparently completely deoxidized by a good carbide slag will make an almost perfect heat of carbon tool steel on one hand, and why on the other hand the same practice will make a heat of chromium steel with thousands of microscopic hair-line seams, the author will not attempt to explain. It is practically proved that the addition of ferrochromium is largely responsible.

Experiments, in which ingots were made by different melting practices and followed through all further processing, proved conclusively that melting to retain a portion of the carbon, manganese and chromium produced uniformly a better product, more nearly free from surface seams and internal hair-lines than melting with complete removal of these elements followed by recarburization on the bare metal.

DEOXIDATION

The deoxidation is accomplished with the customary white or carbide slag. This slag is composed of lime, crushed coke and fluorspar in the proportion of 6 to 2 to 1 and is mixed before being added to the furnace. Best practice with a 6-ton Heroult furnace requires 1 lb. of slag to each 15 or 20 lb. of metal. Under high power



FIG. 1. TAPPING A HEAT OF CARBON CHROMIUM BALL-BEARING STEEL

the slag should be in condition and should carry 1 to 3 per cent calcium carbide within 45 minutes after being applied. By luting the furnace doors to exclude atmospheric air as much as possible 30 minutes further should suffice for an almost complete deoxidation of the bath. A sample for analysis is now quickly taken and all of the ferrochromium and ferromanganese added. Five minutes suffices for the melting of the alloys, after which the bath is well stirred through each door. Further slag additions are now made if necessary and the furnace is again sealed until carbon results are obtained from the laboratory. The results of the analysis will probably show that some recarburization is necessary; addition of carbon is made in the form of washed metal

or low-phosphorus pig iron. When this is melted down, a few shovelful of slag are scattered on the bath and the furnace is again sealed. If the bath appears too hot, the power may be reduced slightly for the remainder of the heat. At least 1 hour should be given to complete the deoxidation after all alloy additions are made.

Results of continued investigations have shown that this period is absolutely necessary if surface seams are to be avoided. It is also advisable to keep the metal very hot during the deoxidation period, a bath temperature of 3,200 deg. F. (estimated) being the best. If, after being under the white slag for 2½ hours, a metal test is "quiet" with no perceptible bulging or sparking, the ferrosilicon is added and the bath stirred as soon as the alloy is melted. Doors are now closed tight and the power is shut off completely for 5 minutes or more or until the metal cools to tapping temperature (3,000 to 3,050 deg. F.). If a heat test and if slag test show temperature and slag conditions correct, the ladle is placed in position and the heat tapped. (See Fig. 1.)

TAPPING AND POURING

In tapping, the slag should be held back completely if possible. On some of the older furnaces it is necessary to use a skimmer for this purpose. More recent types have a tap hole instead of the wider spout, an arrangement that permits the rapid tilting of the furnace until the slag line is above the tap hole. In no case should metal and slag be tapped together, permitting the mechanical intermixing of the two in the ladle. As soon as the ladle is filled, five or six large shovelful of lime are thrown on top and the ladle is held 5 or 10 minutes before pouring. Holding the heat in the ladle during this period is an extra precaution with chromium steels, as it permits the last traces of oxides and entrapped gases to rise to the surface.

The additional wear on furnace and ladle linings by deoxidizing and by tapping exceptionally hot heats is more than justified by reduction in segregation and oxidation defects.

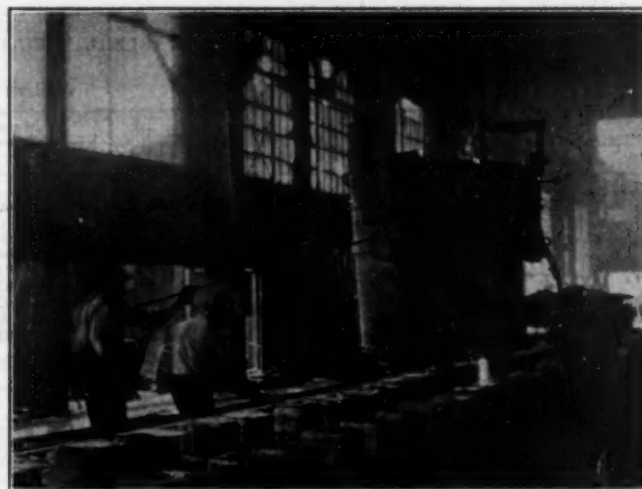


FIG. 2. POURING A HEAT OF CARBON CHROMIUM BALL-BEARING STEEL

With ball-bearing steel it is necessary that every precaution be taken to prevent oxidation or contamination of the metal after it leaves the furnace. Clay ladle washes commonly used should be avoided, as the thin clay coating invariably spalls off and some of it becomes entrapped in the metal.

The most common ingot size for 6-ton heats is 9 x 9 in. The molds may be either solid or split, the former undoubtedly giving the better results. The molds are slightly round cornered, are 9 x 9 in. at the top and taper to 8 x 8 in. at the bottom. Stools accommodate two molds and are so designed that the connection between mold and stool is sufficiently tight that packing is unnecessary. The top is offset in such a way that the sink-head sets 2 in. down into the mold. (See Fig. 2.) The clay sink-heads are dried and warmed over gas burners before being placed on the mold. To prevent sticking, the inside of the mold is slurred with a mixture of hot tar and kerosene oil applied with a long-handled brush. Ingot markers containing the heat and

TABLE I. MELTING WITH PARTIAL OXIDATION

Furnace A. Heat No. 3137			Analysis Ordered																
			C		Si		S		P		Mn		Cr						
			1.00/1.15		0.15/0.25		0.20 max.		0.20 max.		0.25/0.45		1.35/1.65						
Time		Lb.	Metal Tests						Slag Tests										
			C	Si	S	P	Mn	Cr	SiO ₂	FeO	Al ₂ O ₃	MnO	CaO	MgO	CaS†	CaC ₂	Cr ₂ O ₃	P ₂ O ₅	P
5:05 p.m.	Previous heat tapped																		
5:15 p.m.	Bottom repaired—magdolite and dolomite.	300																	
	Began charging—limestone.....	650																	
	Scrap—mixed low phos.....	3,740*	0.40			A bout	0.040												
	Scrap—chromium butts.....	5,240*	1.05	0.20		0.020	0.020	0.35	1.45										
	Scrap—country mixed.....	2,080*	0.30			0.060	0.080												
	Scrap—low-phos. pig iron.....	500*	3.50			0.050	0.040												
	Scrap—scrap shell rounds.....	3,820*	0.60			0.030	0.030	0.60											
						A bout													
5:55 p.m.	All scrap charged—power on.....	15,380*	0.75	0.10	0.035	0.040	0.40	0.50											
8:20 p.m.	Completely melted—added fluorspar	30																	
8:25 p.m.	Began slagging.....		0.59	0.026	0.031	0.012	0.25	0.37	12.75	8.63	3.06	4.08	50.21	14.37	0.041	†	4.72	1.38	.....
8:35 p.m.	Oxidizing slag off.....																		
8:40 p.m.	Deoxidizing slag on—burnt lime....	600																	
	Furnace on high power—powdered																		
	coke.....	175																	
	Fluorspar.....	125																	
8:55 p.m.	Slag partly white.....		0.60	0.031	0.027	0.013	0.26	0.39	14.16	3.07	2.13	0.46	57.03	14.83	1.43	0.13	0.06	.....	0.009
9:10 p.m.	Slag all white, partly carbide.....		0.61	0.031	0.025	0.014	0.26	0.39	14.31	1.01	2.27	0.24	55.86	17.24	1.55	1.47	Nil	.....	0.003
9:15 p.m.	Added ferromanganese, 80% Mn,																		
	6% C.....	20																	
	Added ferrochromium, 65% Cr,																		
	6% C.....	280																	
9:25 p.m.	Bath stirred, slag added.....	50	0.73	0.053	0.015	0.014	0.35	1.51	16.03	0.65	1.86	0.34	56.21	15.46	2.07	1.76	0.32	.....	0.005
9:30 p.m.	Slag strongly carbide.....		0.74	0.055	0.013	0.014	0.35	1.50	14.78	0.34	2.21	0.04	62.17	13.37	2.14	2.13	0.03	.....	Trace
9:50 p.m.	Washed metal added.....	1,000																	
10:00 p.m.	Bath stirred—slag added—power																		
	reduced.....	50	0.96	0.051	0.012	0.014	0.34	1.47	15.67	0.94	1.67	0.05	59.80	14.65	2.23	1.65	0.08	.....	Nil
10:30 p.m.	Heat test quiet—added ferrosilicon,																		
	50% Si.....	65	0.98	0.217	0.012	0.015	0.34	1.46	16.03	0.46	2.03	0.03	60.45	13.86	2.20	1.46	Trace	.....	Nil
10:45 p.m.	Slag strongly carbide—bath stirred.		1.00	0.214	0.011	0.015	0.34	1.46	16.47	0.33	1.98	0.04	61.31	13.53	2.46	2.64	0.02	.....	0.003
10:50 p.m.	Metal hot—power shut off.....		1.01	0.217	0.011	0.015	0.35	1.46	15.85	0.37	2.11	0.03	60.93	14.21	2.31	2.02	Nil	.....	Ni
10:55 p.m.	Heat tapped.....																		
	Ladle.....		1.05	0.209	0.011	0.015	0.34	1.47	17.01	0.43	2.26	0.04	59.37	13.81	2.36	1.87	Trace	.....	0.004

Total ingot weight, 15,900, or 95.4 per cent.

*Analysis of scrap approximate.

†Reported as sulphur.

TABLE II. MELTING WITHOUT OXIDATION

Furnace A. Heat No. 3209		Analysis Ordered																
		C		Si		S		P		Mn		Cr						
		1.00/1.15		0.15/0.25		0.20 max.		0.20 max.		0.25/0.45		1.35/1.65						
Time		Lb.	Metal Tests						Slag Tests									
			C	Si	S	P	Mn	Cr	SiO ₂	FeO	Al ₂ O ₃	MnO	CaO	MgO	CaS	CaC ₂	Cr ₂ O ₃	P
3:25 a.m.	Previous heat tapped.....																	
3:40 a.m.	Bottom repaired—magdolite—dolomite..	250																
3:45 a.m.	Began charging—limestone.....	50																
	Scrap—chromium steel crops.....	7,870*	1.05	0.20	0.015	0.015	0.38	1.45										
	—scrap rounds.....	3,260*	1.10	0.20	0.018	0.016	0.37	1.40										
	—ball scrap.....	3,010*	1.00	0.15	0.020	0.020	0.40	1.35										
	—chisel steel scrap.....	1,380*	0.70	0.10	0.020	0.014	0.35											
			Average															
			1.01	0.18	0.018	0.015	0.38	1.27										
4:30 a.m.	Scrap all charged—power on.....	15,320*																
4:50 a.m.	Charge nearly melted.....																	
	Began adding deoxidizing slag																	
	Burnt lime.....	550																
	Powdered coke.....	150																
	Fluor spar.....	100																
7:05 a.m.	All melted—all slag charged.....		0.94	0.047	0.017	0.015	0.32	1.11										
	Furnace on High Power																	
7:30 a.m.	Slag white—partly carbide—added slag..	50	0.95	0.050	0.014	0.016	0.35	1.16	13.41	2.06	1.37	0.45	59.21	14.17	1.17	0.56	0.43	0.011
7:45 a.m.	Added ferromanganese, 80% Mn, 6% C...	10																
	Added ferrochromium, 65% Cr, 6% C....	75																
7:55 a.m.	Slag strongly carbide—bath stirred.....		1.00	0.057	0.013	0.017	0.39	1.50	15.17	0.63	1.57	0.21	61.07	13.62	1.57	1.78	0.31	0.006
8:20 a.m.	Slag strongly carbide—added slag.....	75	1.02	0.059	0.012	0.017	0.38	1.48	16.21	0.47	1.86	0.06	60.27	13.17	1.63	1.51	0.06	0.002
8:30 a.m.	Slag strongly carbide—metal test quiet..		1.03	0.056	0.012	0.017	0.39	1.50	15.37	0.31	1.76	0.05	59.07	15.47	1.58	2.11	0.07	Trace
	Added ferrosilicon, Si 30%.....	60																
8:40 a.m.	Bath stirred.....		1.04	0.247	0.011	0.017	0.39	1.48	17.31	0.41	1.73	0.07	57.36	14.09	1.69	1.32	0.03	Nil
8:45 a.m.	Slag O.K.—metal O.K.—bath hot—		1.04	0.243	0.011	0.017	0.38	1.48	18.07	0.35	1.67	0.05	58.41	14.71	1.78	1.47	0.06	Nil
8:55 a.m.	power off.....																	
	Heat tapped.....																	
	Ladle.....		1.08	0.240	0.010	0.018	0.39	1.49	19.31	0.41	1.83	0.07	56.93	14.88	1.69	1.67	0.02	0.003
Total ingot weight, 15,030 or 95.9 per cent.																		
*Analysis of scrap approximate.																		

Total ingot weight, 15,030 or 95.9 per cent.

*Analysis of scrap approximate.

ingot number are placed in the top of the ingot as soon as poured.

Pouring should be as rapid as possible and through a 1½-in. nozzle; the temperature at the start should be about 2,950 to 3,000 deg. F. Extensive pouring tests covering months have shown that direct pouring when handled correctly is by far the best for chromium steels. After trying all possible forms of box and pot pouring, these were finally abandoned in favor of the direct-poured practice. This practice at an initial temperature of 2,950 deg. F. leaves, after pouring fourteen to seventeen ingots, a slight skull of 50 or 100 lb. in the ladle.

The ingots are covered with a mixture of lime and powdered coke and no special precautions are taken to eliminate pipe. The temperature and pouring practice just described practically eliminates possibility of secondary pipe and throws the main pipe and all segregation well up into the sink-head, where it is cropped and scrapped.

The ingots are stripped 90 minutes after pouring and placed in a pit, where they are covered with ashes for 36 to 48 hours. Table I shows the chemical history of a heat of chromium ball steel melted with partial oxidation; Table II shows the same kind of steel, the charge being wholly chromium steel scrap and melting being under a white slag.

PROCESSING

The ingots are chipped, if necessary, to remove any pits, pock marks or metal shots. A little chipping of the ingots will frequently save much chipping labor after roughing to billets. The ingots are then reheated for rolling. It is a characteristic of chromium ball steel that with the exception of internal hair-lines most defects if present will be found on or very close to the surface. For this reason the heating for initial rolling should be controlled so as to produce free and heavy scaling. If forging billets are made, rolling is direct, 10 per cent top discard and about 5 per cent bottom discard being scrapped. When large bars (2 to 4 in.)

are made, and this constitutes the most important and the bulk of the chromium steel business, two procedures are followed—direct rolling and roughing and re-rolling. The latter method unquestionably produces the best result and will be described in detail. For the large size rounds (2 to 4 in.) the ingots are heated to a free scaling temperature and roughed to 4- to 6-in. gothic billets. The top, 3 or 4 in. below the sink-head, is nicked on all sides by the hot saw and the bottom discard of about 5 per cent completely removed by the saw. The billets are rolled onto the hot bed and placed in close contact with one another, being covered in cold weather with a layer of lime or ashes. Finishing temperatures, while not so important in the roughing, should not be too high.

After cooling, the sink-head end of the billet is removed by breaking and the fracture examined for pipe. In case this appears, the billet is nicked back 6 in. with an acetylene torch and again fractured, which process is repeated until there is no evidence of pipe. The top discard in this class of steel should never be below 10 per cent and preferably should approach 15 per cent.

After fracturing, the billets are pickled and chipped clean from any seams or flaws. If melting was correctly accomplished, chipping should be slight. The billets are then reheated and rolled to finished size, excessive scaling being prohibited in the finished rolling, which is done with careful attention to surface appearance and finishing temperature, the latter being near the critical range, 1,375 to 1,400 deg. F.

At this point both top and bottom discard from the finished bars representing the first, middle and last ingots of each heat are sent to the laboratory and analyzed for carbon, manganese and chromium. If the maximum variation among the six tests on the heat does not exceed 0.05 per cent on each element, segregation is considered absent. By the method above outlined, fracturing top discard on roughed billets and re-rolling, segregation is practically impossible with good melting and pouring practice.

The bars are given a close file inspection for seams

and one bar from each heat is selected for hair-line tests. The inspected bars are then annealed. Consumers of this grade of steel require that chromium steel bars be soft enough for satisfactory work in automatic machines—that is, 170 Brinell or below—and that bars pass rigid hardening tests. To fulfill both requirements means that in annealing, all cementite, both excess and combined with the pearlite, must be spheroidized. This is very essential if the complete absorption in hardening, which is necessary for a uniform martensitic structure, is to be attained.

All bars above 1 in. in size must be normalized as well as annealed. To this end and to prevent decarburization the bars are packed in heavy walled cast-iron pipes, 14 in. in diameter and 16 ft. long. Any spaces not occupied by the steel are filled with a mixture of charcoal and ashes and the ends sealed with brick and fireclay.

To facilitate rapid and economical handling during normalizing and annealing, a car type furnace is used, with doors at both ends. Two cars are provided, being fastened together. Car No. 1, being loaded, is pulled into the furnace, the doors are closed and sealed and the furnace is fired. The mass is heated as rapidly as possible to 1,725 to 1,750 deg. F. and then held at this temperature for 12 hours. While at this temperature car No. 2 is loaded. After the 12 hours' heating at normalizing temperature the furnace doors are opened, car No. 1 is drawn out, No. 2 being drawn in at the same time. After car No. 2 is held at temperature (1,725 to 1,750 deg. F.) for the specified time, it is withdrawn, car No. 1 being drawn in simultaneously and the open furnace now cooled rapidly to 900 deg. F. or slightly below. The doors are then closed and the first lot is now heated at the rate of 20 deg. per hour to 1,400 to 1,420 deg. and held at this temperature for 24 hours. Cooling is at the rate of 10 deg. per hour down to 800 deg. F., when the doors are opened and car No. 1 is withdrawn. While this charge is cooling and the pipes are being unloaded and recharged, car No. 2 is being annealed at 1,400 to 1,420 deg. F. for 24 hours, with subsequent slow cooling as in the case of car No. 1.

This method of annealing insures complete spheroidizing of all the carbide and produces a steel which will range from 155 to 165 Brinell.

After unloading, the bars are run through a machine that straightens and imparts an oiled polish to the surface. A disk $\frac{3}{8}$ in. thick is cut from every third bar for hardening tests. The steel is now ready for shipment.

ROUGH TURNING CHROMIUM BEARING STEEL

An extensive study of comparative costs and quality of product was made between the practice above described and the following. Knowing that the majority of defects in chromium steel (aside from hair-line seams, which will be discussed later) are surface seams, another method was tried to eliminate these. The ingots were chipped, reheated and rolled to finished size direct in the case of the larger bars, roughed to gothic billets and finish rolled to size in the smaller bars. In all cases finish rolling was $\frac{1}{2}$ in. full. The bars were open annealed, straightened and rough turned to size. Inspection was after rough turning. This practice eliminated pickling, much of the chipping and the extra pipe cost in annealing. The product was undoubtedly better in appearance, was somewhat freer from seams than the

regular product and on the basis of cost studies could be made just as cheaply as the regular product. The only objection to regularly rough turning chromium steel is the large amount and excessive cost of the equipment necessary to handle a considerable tonnage in this manner. In a plant where this equipment was available this practice would be preferred as producing the best product possible.

HARDENING TESTS

These tests are made to determine the correctness of the normalizing and annealing operation and to determine whether all of the cementite is completely spheroidized. The disks cut from the finished bars are placed in a small gas-fired or electric heat-treating furnace and brought to 1,435 to 1,450 deg. F. and held at this temperature for 20 minutes. They are then withdrawn and immediately quenched in cold water. With a sledge the disks are broken in half and the fracture of the hardened steel is examined. A perfectly annealed piece results in a fracture that is very fine grained, silky and silvery in appearance. Dark streaks or spots due to undissolved carbides should be entirely absent.

TESTS FOR HAIR-LINE SEAMS

One annealed bar about 6 ft. long is picked from each heat, straightened and rough turned to remove scale. It is then placed in a lathe, 6-in. sections being turned down so that each section is progressively $\frac{1}{8}$ in. smaller in diameter than the preceding. A $3\frac{1}{2}$ -in. round bar 6 ft. long will have twelve sections ranging from $3\frac{1}{2}$ in. down to $\frac{3}{4}$ in. diameter, exposing successively the whole bar from center to surface. With a reading glass that magnifies about five diameters the bar is closely examined and the number of hair-line seams on each section counted.

THE HAIR-LINE

The following peculiarities and characteristics of the hair-line seam have been noted by the author in the past 5 years. This defect is a very small, almost microscopic crack in the bar, always running in the direction of rolling. It is undoubtedly an elongated hole caused by very small particles of gas being entrapped in the steel. It may be present in any part of the bar and is apparently well distributed throughout the mass of metal. It is a spot of weakness and, due to the drastic hardening treatment accorded to this grade of steel, will form a spot from which ultimate failure of the hardened ball or ball race will originate. It is a defect that is found in appreciable amounts in this grade of material only, it being especially evident when the chromium content is around 1.50 per cent and the carbon 1.00 per cent. The best melting practice will reduce the number of hair-lines present, but will not eliminate them entirely.

Given a uniform melting practice, uniform conditions of rolling and annealing, the hair-line seam will appear in steel in which high-carbon (6 to 8 per cent) ferrochromium was used, but will be almost entirely absent in steel made from 2 per cent carbon ferrochromium. A heat made from ball steel scrap entirely, scrap consisting of billet crop ends and bars rejected on account of seams and hair-lines and melted under a white slag without oxidation, will be almost free from this defect. Some shipments of 6 per cent carbon ferrochromium produce a steel badly contaminated with hair-line seams, while other shipments of the same class of alloy will produce

a steel with few of these defects. Steels made from 6 per cent carbon ferrochromium purchased in 1916 and 1917 were singularly free from hair-lines, while steels made from the same alloy made under pressure of war conditions in 1918 and 1919 were badly contaminated.

From these facts it is probable that in the ferrochromium lies the origin of the hair-line seam. Melting with as little oxidation as possible in the presence of a strongly carbide slag and adding the ferrochromium as early in the heat as possible will help to reduce the number of the hair-line seams.

While the origin of the hair-line has been accounted for by a well-developed theory, lack of conclusive evidence to substantiate this theory makes it unwise to publish it at this time.

Another interesting fact in connection with chromium steel of the above composition: The author had noted for some time the peculiarity of the relative solubility of chromium steels in nitric acid. Treatment accorded to all ladle test samples of chromium-bearing steel was as follows: The small test ingot was stripped from the mold as soon as solid and buried in a bucket of lime for 45 minutes. It was then quenched in water and drilled at slow speed with a high-speed drill. The drillings were screened and 5 g. of the steel that passed 20 mesh and was retained on 40 mesh was digested just below the boiling point with 100 c.c. of dilute nitric acid, sp.gr. 1.16. Some of the steels dissolved completely in 15 or 20 minutes, others dissolved much more slowly, and still others, notably white slag heats, were practically insoluble. In conjunction with the inspection department an attempt was made to correlate these phenomena with the quality of the steels. In every case it was found that rejections were the highest on those heats whose drillings dissolved most easily in nitric acid, while the heats whose drillings dissolved with great difficulty or were practically insoluble were free from surface seams and internal hair-lines. By means of this test the chief inspector was prepared several days in advance and had an accurate idea of the quality of the steel he was to pass upon.

The relation between solubility and hair-lines was especially noticeable. After a few trials it was possible to foretell with fair accuracy the percentage of rejections on this account. The accuracy of the solubility test, however, is absolutely dependent upon the degree of hardness of the test-piece drilled. It is comparative only and fails utterly unless all ladle test-pieces have been similarly treated and unless all are fairly hard. The least softening of the steel affects its solubility very markedly and comparisons are then impossible.

DEOXIDIZING BALL-BEARING STEEL WITH FERRO-TITANIUM AND FERROVANADIUM

Several heats of this steel were made using ferro-titanium as an additional deoxidizing agent. In some heats the titanium alloy was added to the furnace after the ferrosilicon and just before tap. Two to three pounds of the alloy was used for each ton of steel and the melt was well stirred after the addition. In other cases the alloy was thrown into the ladle as soon as the bottom was covered with metal. In both cases the steel was held in the ladle 5 to 10 minutes before pouring.

A few heats to which sufficient ferrovanadium was

added to the metal to give a vanadium content of 0.03 to 0.05 per cent were made and processed for comparative tests. No departures were made from the usual practice in processing from the ingot to the finished bar. Inspection and hair-line tests showed that both alloys produced a steel slightly superior to the regular product. It is questionable, however, whether the slightly better results were justified by the increased cost, especially in the case of ferrovanadium.

SUMMARY

From the results of 5 years' experience on high-carbon, high-chromium ball steel the following was adopted as the practice productive of the most satisfactory steel at the lowest cost:

Melt selected scrap with partial oxidation to eliminate phosphorus and to retain most of the carbon, manganese and chromium. Deoxidize with a strongly carbide slag, excluding atmospheric air from the furnace as much as possible and adding the ferrochromium as soon as the metal is deoxidized and the slag in good shape. Allow at least 1 hour for further and complete deoxidation after the alloy has been added. Deoxidize on a very hot bath and tap metal at about 3,000 deg. F. or a little above, holding 5 to 10 minutes in the ladle before pouring. Bury ingots for at least 36 hours in ashes.

Chip ingots and reheat, permitting them to scale freely. Rough to a gothic billet and fracture to expose possible pipe. Pickle, chip and reheat for final rolling. Roll to finished size with particular attention to finishing temperature. Inspect for seams, normalize, air cool and anneal for 24 hours at 1,400 to 1,420 deg. F. with slow furnace cooling. Machine straighten. Adherence to this practice, provided a clean ferrochromium is used, will produce a product free from surface defects and with a minimum of hair-lines.

Charleston, W. Va.

Effect of Upper Silesian Plebiscite on Chemical and Metallurgical Industries

The *Chemisch-Technische Industrie* estimates that the result of the partition of the plebiscite area in Upper Silesia is to give Poland nearly 76 per cent of the coal production, 96.9 per cent of the iron ore production, 81.9 per cent of the zinc ore, 70.9 per cent of the lead ore and 26 per cent of the sulphur ore. Of the production of coke 50.6 per cent and of coke byproducts 50.2 per cent goes to Poland. The zinc and zinc byproducts industries and the lead and lead byproducts industries fall entirely into the hands of Poland, with 43.8 per cent of the petroleum-refining industry and 75.6 per cent of the coal-distillation industry. Poland also obtains the whole sulphuric acid industry.

Preparation of Synthetic Organic Chemicals at Rochester

The address on "The Preparation of Synthetic Organic Chemicals at Rochester" presented by Drs. C. E. K. Mees and H. T. Clarke before the Society of Chemical Industry, Montreal, Aug. 31, 1921, has been published in the form of an illustrated booklet, copies of which are obtainable upon request from the Eastman Kodak Co.

As a natural consequence of the attempt to produce a great variety of highly specialized products, methods for carrying out organic syntheses were developed which should be of interest to organic research workers in general. Typical set-ups are illustrated and many novel features explained.

²Standard test No. 1; an ingot 1½ x 1½ x 8 in. high, top flared to act as sink-head. See p. 4, U. S. Steel Corporation pamphlet "Methods for the Commercial Sampling and Analysis of Plain Steels."

Manufacture of Phosphoric Acid and Phosphates

General Treatise on the Acid-Decomposition Process in Industrial Production—Dissolving the Raw Ore—Removal of Impurities—Monocalcium and Dicalcium Phosphates—Concentration and Grading of the Salts—Production of Sodium Salts From Phosphoric Acid

By JACOB T. MECKSTROTH
Consulting Engineer, Columbus, Ohio

THE manufacture of phosphoric acid and phosphate salts may be divided into two general processes. One is called the pyrolytic or volatilization, the other the acid-decomposition process.

The pyrolytic or volatilization process is at present used only in the manufacture of the highest grade of the so-called chemically pure phosphoric acid. This process has not yet been developed to the commercial efficiency of producing an acid at a cost to compete favorably with the acid-decomposition process. There is, however, no doubt that the day is not far distant when the pyrolytic or volatilization process, as described by Waggaman and Wagner in the *Journal of Industrial and Engineering Chemistry* for May, 1918, and reported by Waggaman and Turley in the *Journal of Industrial and Engineering Chemistry*, vol. 12, 1920, p. 646, and in *CHEMICAL & METALLURGICAL ENGINEERING*, vol. 23, p. 1057, 1920, will become a commercial possibility and a strong competitor to the acid-decomposition processes.¹

ACID-DECOMPOSITION PROCESS

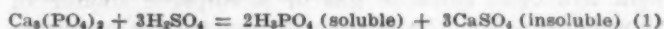
The process of decomposition, by means of 60 to 66 deg. Bé. sulphuric acid, is today the best developed and commercially successful, yet it is far from being satisfactory. The larger proportion of the acid is manufactured from phosphate rock, a tricalcium phosphate, with an admixture of silica and fluorspar, often called apatite or phosphorite. In the United States the important beds or deposits of this rock are found in Tennessee, Kentucky, Florida, South Carolina, Idaho and Montana. It is generally sold or purchased on a guaranteed basis of 75 to 80 per cent tricalcium phosphate, $\text{Ca}_3(\text{PO}_4)_2$, and its color varies from blue-green or gray to red-brown. The Tennessee and Kentucky rock has a color varying from blue to brown and has generally a higher percentage of iron and aluminum than the Florida, Idaho or Montana rock. The blue grade is usually lower in iron and aluminum than the brown grades, but is lower in the P_2O_5 content.

The Idaho and Montana deposits are being developed at the present time and are considered equal to if not actually better than either the Tennessee or Florida grade. On account of location and unknown quantity these deposits have not received the attention to which they are entitled and which they should receive. Large sums of money are being expended to utilize both the sulphuric acid from the smelter industry and the rock of the Montana and Idaho regions.

The rock deposits are frequently purchased outright by the manufacturer, although often concessional rights for a definite tonnage of definite quality are contracted for, and sometimes the rock is bought as run of mine

and shipped to the plant where the grinding is done. The rock is mined by removing the overlying earth, separating the high grade by hand picking, washing, grinding and loading it in cars of approximately 40 tons capacity, to be transferred to the plant for its decomposition, purification and refining.

The disintegration of the rock begins with the mixing of definite quantities of water and acid or a weak acid with a weighed quantity of the ground rock. The following reaction takes place:



Remaining behind with the calcium sulphate in treatment of the apatite with sulphuric acid are impurities natural to apatite such as AlPO_4 , FePO_4 , unconverted CaF_2 , SiO_2 , etc. The H_3PO_4 filtrate carries with it as impurities more or less of the AlPO_4 and FePO_4 , rendered soluble by the chemical action of the sulphuric acid. There is also some HF in the H_3PO_4 .

During the mixing considerable heat is developed which may be controlled by the process of mixing or by the size of the mixes made. The mixing is best done in a lead or acid-resistant brick-lined tank of appropriate size. The agitation required during the mixing is such that mechanical stirring devices must be provided. Air agitation is quite expensive and unless the bath is heated is not to be recommended. Air cools the mixture, prevents efficient reaction and is often detrimental to the separation of the liquid from the solids. Ninety to 95 per cent of the reaction is complete in 1 hour after the last of the ingredients has been added—that is, if proper proportions are used.

REMOVAL OF IMPURITIES

The removal of the insoluble and soluble impurities, consisting of the calcium sulphate, silica, as well as the compounds of iron and aluminum, fluorine, arsenic and lead, constitutes the problem of the phosphoric acid manufacturer.

The procedures for removing the various impurities differ with different manufacturers. It is possible to combine the removal of some of these impurities in one operation, and in order to decrease the number of processes it might be mentioned that the arsenic and any lead which may be present can be precipitated by treating the decomposition mixture with hydrogen sulphide gas. This leaves the insoluble arsenic sulphide, lead sulphide, calcium sulphate and silica, which may be separated or filtered from the soluble acid and impurities in one operation. By means of the counter-current decantation system or by means of filter presses, the insoluble calcium sulphate and silica may first be separated and the resultant liquid acid treated for the removal of the arsenic, which involves another filtering operation. The calcium sulphate is practically a worthless product, hav-

¹See also *CHEM. & MET. ENG.*, vol. 24, No. 11, March 16, 1921, p. 466, and vol. 25, No. 11, Sept. 14, 1921, p. 517.

ing a brown or chocolate or gray color. However, it may sometimes, if calcined, be used for the manufacture of ceramic products such as plaster, building blocks and tile.

After the removal of the calcium sulphate and silica, any weak liquid acid obtained in the process may be used in place of water for mixing in the decomposition tanks. By using a phosphoric acid of 16 to 18 deg. Bé. with 60 deg. sulphuric acid, an acid of 28 to 30 deg. Bé. can easily be obtained, which will contain from 37 to 40 per cent phosphoric acid depending upon conditions in the mixing. A liquid of almost any density and acidity may thus be obtained. It is economically impossible to remove all the soluble P_2O_5 from the insoluble calcium sulphate by washing. There is left, usually, from 1 to 2 per cent soluble, besides from 1 to 2½ per cent insoluble P_2O_5 , calculated on a dry basis of the sulphate residue. From 1 to 2½ per cent of calcium sulphate will be held in solution by the liquid acid, part of which will, however, settle out upon standing.

REMOVAL OF ARSENIC, IRON, ALUMINUM AND FLUORINE

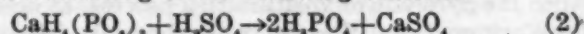
To remove the soluble arsenic, treat the filtered liquid with hydrogen sulphide gas or a sulphide soluble in phosphoric acid. The latter will produce the hydrogen sulphide gas, which in turn will react with the arsenic in solution and form the insoluble arsenic sulphide. It is true that hydrogen sulphide is a dangerous and very objectionable chemical to use on account of its poisonous characteristics or properties. However, with the proper precautions, such as ventilating and aerating, all danger can be eliminated. After the arsenic has been completely precipitated or thrown out of solution the mixture or the acid liquid may be aerated by means of compressed air to remove the hydrogen sulphide gas before the filtration operation is to take place. The presence of hydrogen sulphide gas during any filtering or transferring operation is indeed objectionable even in small or dilute quantities. Hydrogen sulphide often produces colloidal sulphur or colloidal arsenic sulphide, which causes difficult filtration, but by having the mixture or liquid acid heated to not less than 40 to 65 deg. C. no trouble should be experienced. A clear liquid of straw color, practically free from arsenic and lead, is thus obtained.

The economical removal of the iron, aluminum and fluorine constitutes probably the most difficult problem of the phosphoric acid manufacturer. As in the case of the removal of calcium sulphate from the crude acid, a small percentage of these elements will remain in solution. Their removal may be accomplished in one treatment and one filtering operation. The phosphoric acid containing as impurities HF and iron and phosphates in solution can be purified by heating with carbonates or hydroxides of the alkalis or the alkaline earths. This brings about a precipitate, say if $CaCO_3$ is used, of the HF as CaF_2 . The iron and aluminum salts also precipitate as $FePO_4$ and $AlPO_4$, respectively.

The insoluble iron and aluminum phosphate, the insoluble fluoride, together with some of the phosphate, which invariably combines or becomes insoluble during the specific treatment involved, may be removed either by the counter-current decantation process, or by using a wooden frame press, a box filter with pressure or vacuum or a rotary filter of the Oliver type. By adding sufficient amounts of alkali salts, all but the last traces of iron, aluminum and fluorine are removed from solution.

This insoluble material, after filtration and washing, is dried and sold to the fertilizer manufacturer. The dried product usually contains from 30 to 35 per cent of P_2O_5 , depending on the care taken to perform the operation and the percentage of moisture it contains. The strength and specific gravity of the original crude acid and the temperature of the mixture during the operation are important factors to consider and need careful supervision and attention. A crude acid of 13 deg. Bé., for example, can be treated at ordinary temperature and good settling or filtration will result, whereas a crude acid of 25 to 28 deg. Bé. should be heated and very carefully treated to avoid any unnecessary loss and to produce a filtrable mixture.

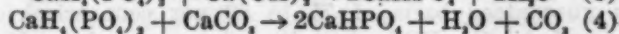
The filtrate from this operation should have only a very small percentage of free acidity, but considerable phenolphthalein acidity or so-called total acidity. This liquid may be used in the production of a purified or edible phosphoric acid or dicalcium phosphate in the event a calcium alkali was used in the treatment. By treating the monocalcium phosphate solution with sulphuric acid free from iron, aluminum, arsenic and lead the insoluble calcium sulphate and phosphoric acid practically free of iron, aluminum, arsenic and lead are produced according to the following reaction:



The calcium sulphate precipitated is a very white crystalline product, settles very readily and may be separated from the liquid acid by filter presses, by filter boxes, by the counter-current decantation system or by an acid-proof rotary filter. The white calcium sulphate after being thoroughly washed to remove the soluble phosphoric acid is either discarded or used in the manufacture of sulphated goods or materials. The dilute acid may be either marketed or concentrated to any desired strength and used in the manufacture or production of monocalcium phosphate or sold as concentrated liquid phosphoric acid.

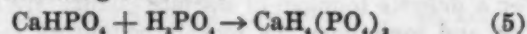
PRODUCTION OF DICALCIUM PHOSPHATE

The monocalcium phosphate solution may be treated with milk of lime, hydrated lime or calcium carbonate, according to following reaction:



In the production of the dicalcium phosphate, the concentration and temperature of both the milk of lime and acid solution play an important part in the process. As a general rule, the more dilute solution and higher temperatures give the higher grade product, both as to chemical and mechanical characteristics. There is little choice between using milk of lime or the hydrated lime except that the hydrated lime is the higher in price. The use of calcium carbonate, often called marble dust, is not recommended, on account of undecomposed carbonate resulting in the finished product.

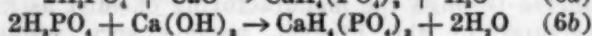
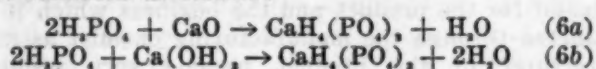
The dicalcium phosphate is a white, crystalline product and may be separated by means of filter presses or boxes or settled in a Dorr thickener and filtered by a rotary type filter. Then it is dried by steam and with vacuum iron driers and ground to any mesh desired. This neutral product is invariably used by the manufacturer in the production of the mono-acid salt, according to the following reaction:



The production of tricalcium phosphate may be accomplished by adding a solution of sodium phosphate to

a solution of calcium chloride in the presence of ammonia, washing the precipitate free from chlorides and ammonia, drying and grinding the product to a fine white powder. The ammonia and chloride may be recovered and again utilized.

As stated above, the weak purified liquid phosphoric acid, having a straw color, may be concentrated to a Baumé of 50 to 53 deg. and used in the manufacture of the mono-acid salt, according to reaction 5 or by the addition of ground, burnt lime or hydrated lime according to reactions as follows:



CONCENTRATING, FILTERING, GRINDING AND GRADING

During the concentration the acid invariably becomes dark in color, and common practice is to add oxidizing agents, such as chlorates or permanganates, until practically a water-white liquid is obtained. Care must be taken not to add the oxidizing agent in excess, on account of the presence of manganese, originally in the rock or in the permanganate used in the bleaching, which will cause the acid to turn a pink or a deep purple color. The concentration may be accomplished by passing the weak liquid acid over lead steam coils, through acid-resistant brick concentrators, or it may be concentrated by means of hot air-spraying systems.

The separation of small crystals of calcium sulphate from the hot solutions during the concentration process is troublesome, especially where lead steam coils are being used. These steam coils continually become coated with a hard sulphate scale, which must be removed by treating them with a solution in which the scale is soluble, by hammering or by picking the coils. This latter is a rather tedious and destructive method and contaminates the acid with lead. If an acid-resistant brick constructed concentrator is used, an occasional cleaning out is necessary, but no trouble with lead contamination is experienced.

Before the concentrated acid is to be mixed with the alkali or neutral salt to produce the mono-acid salt, the precipitated or insoluble calcium sulphate is removed by filtration. A small amount of calcium carbonate or dicalcium phosphate may be added before the filtering takes place. This will not only lower the percentage of soluble sulphate but will also cause the lead sulphate, if any is present, to be incorporated in the finely divided precipitate and be removed by filtration. The filtration may be accomplished with wooden frame filter presses, using air pressure or force pump. The acid, now ready for the production of the acid salt, is weighed and added slowly, under continual agitation, to a weighed amount of the alkali or neutral salt and thoroughly mixed. As the reaction requires considerable time for completion, it is advisable to add a slight excess of acid and then give ample time for the reaction to go to completion and all the free acid to disappear. At least 24 to 48 hours should be allowed for this aging process to take place. After proper aging, the acid salt is dried at a temperature of approximately 85 deg. C., preferably in a rotary or shelf vacuum drier, until a product containing not over 1 per cent moisture is obtained. A higher moisture content is detrimental both to the grinding or milling process and in the baking chemicals in which it is to be used.

The grinding of the acid salt is not a difficult operation. Under unfavorable weather conditions, considerable caking takes place, especially in damp climates.

The grinding is followed by the screening operation, in which the powdered and granular portions are classified.

After the acid salt is properly granulated or powdered, it may be standardized to any strength desired by the addition of a neutral or inert substance, such as corn starch, dicalcium phosphate or calcium sulphate. The calcium sulphate cannot be classed as an inert substance and the present tendency is to eliminate the so-called sulphate phosphate from the baking industry. The leading phosphate manufacturers are taking the initiative and advising their customers to use only the full strength or the higher test phosphate.

It is sometimes the custom of the baking powder manufacturer to have the starch incorporated in the phosphate, by having the phosphate and starch mixed in a wet state before the drying and milling process.

The following analysis is typical of a high strength and a good grade of phosphate for baking or leavening purposes:

	Per Cent
Free phosphoric acid (H_3PO_4)	None
Monocalcium phosphate $\text{CaH}_2(\text{PO}_4)_2$	88.50
Dicalcium phosphate $\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$	8.00
Calcium sulphate (CaSO_4)	1.00
Iron and aluminum phosphates	1.00
Moisture and insoluble	1.50
Arsenic and lead, both under government allowance.	

The dicalcium phosphate often may be found as high as 12 to 14 or as low as 1 to 2 per cent, the iron and aluminum, the calcium sulphate and the moisture each as low as 0.5 per cent and as high as 4 to 5 per cent.

PRODUCTION OF SODIUM PHOSPHATES

In the production of sodium salts of phosphoric acid the crude acid, as obtained in the decomposition process, is treated with soda ash or caustic soda instead of with lime for the removal of the soluble impurities. The soluble iron and aluminum salts become insoluble and are removed by filtration. The monosodium liquid may be concentrated and used for the production of crystalline or powdered monosodium salt. This monosodium salt may be used for the production of the sodium acid pyrophosphate, which is practically non-hygroscopic and a desirable acid leavening chemical. Or the monosodium salt solution may be treated with caustic or sodium hydroxide to form the neutral disodium salt or the alkaline trisodium phosphate. In the production of the trisodium salt, the solution may be concentrated to from 28 to 38 deg. B \acute{e} . in large iron boiling tanks or boxes by means of iron steam pipes, and crystals of the salt are obtained upon cooling. The mother liquor is used repeatedly until it is too dark in color and must then be discarded or be used in the production of substances such as dark laundry soaps or boiler compounds, etc.

BONE AS A SOURCE OF PHOSPHORIC ACID

Phosphoric acid and phosphates are produced from bone by treatment with sulphuric acid. The bone used for this purpose may be either the burned or unburned bone of the large packing industry or the discard or spent bone black of the oil and sugar industries. If care is taken in the selection of the bone, a very good grade of phosphoric acid can be prepared, from which neither the iron and aluminum nor the fluorine needs to be removed as is the case in rock phosphate. The weaker acid obtained may be treated for arsenic and lead as described for rock phosphate, then concentrated and used as liquid acid for the production of the salts or sold as concentrated liquid phosphoric acid.

Legal Notes

BY WELLINGTON GUSTIN

A Point on Steamship Shipments

The Distilleries Chemical Supply Co. filed a libel suit against the steamship *Devona* to recover for freight paid for a shipment of formaldehyde and acetic acid, which was put on board and then taken off, at the captain's direction, before the boat sailed. It appeared that the vessel was chartered by the C. H. Pattingill Corporation, and that the freight was paid to the Caravel Steamship Lines, Inc., agent for the latter corporation. It appeared that the boat's owner was willing that the Caravel Steamship Co. might book freight for the vessel.

The case was tried in the Federal District Court. The claimant urged that no action against the boat would lie to recover freight, even if the goods are received on board ship, unless the owner received the amount paid, with which proposition the court agreed. And the admitted receipt of goods on board does not necessarily make the ship liable for damages for failure to transport. (The *Esrom* C. C. A., 272 Fed., 266.)

The trial court said there was nothing to indicate that the claimant intended to give the Caravel Steamship Lines authority to bind the ship by the receipt of freight, and the equities are with the claimant, which is asked to return moneys which it never received and which it never authorized another to receive in its behalf. Judge Hough laid down the principle applicable in the *Saturnes* (250 Fed., 407), wherein he said: "This litigation exemplifies a common tendency to regard any floating property, used in the performance of contract, as in some sort of a pledge or surety for satisfactory performance; such security to be enforced by asserted maritime lien. No such principle is known to the admiralty."

Therefore, the court dismissed the action of libel against the steamship but gave a decree against the Caravel Steamship Lines.

Lincoln Chemical Company Fails in Tax Case on Its Process

The case of the Lincoln Chemical Co. vs. Edwards, as Collector, reported in 272 Federal, 142, was to recover a refund of a part of the excess profits tax for 1917. The case depended on the meaning of the phrase "invested capital" and "nominal capital" as used in section 209 and as defined in section 207 of the revenue law of 1917. The company filed its return for 1917 and calculated its capital upon the basis of section 209—that is, it assumed it had "no invested capital," or not more than a "nominal capital." The treasury officials re-assessed the tax at a larger figure upon a basis that plaintiff had incorrectly applied section 209.

The chemical company was organized under the laws of New York with a capital stock of \$10,000 by two persons, Riddle and Loeb. Riddle was an inventor and came to Loeb with a process for extracting cocoa butter out of cocoa shells, a byproduct. This process proved worthless, and Riddle continued his experiments to convert the process into one from which he could extract from cocoa shells a chemical

substance, known as theobromine, allied to caffeine. Loeb incorporated the company to carry out the venture. Nearly \$20,000 was spent in Riddle's further experiments upon the process in 1910, when it was completed. A contract was made with a manufacturing chemist to exploit the process on a royalty basis, but the sales of theobromine were so few that the royalty was never earned. All the company's assets were used up by 1914.

The company never manufactured any theobromine after 1910. The Great War in 1914 increased the demand for the product and the business which it conducted through the manufacturing chemist as manufacturer of the product became very profitable. During 1917 the assets of the company, therefore, consisted only of its cash on hand, the contract with the chemist for the manufacture of the product which was resold and the secret process finally perfected by Riddle. Its stock was \$10,000 and its surplus, as stated, \$13,000, of which over \$7,000 was in cash. Its other assets were valued at \$16,000.

PLAINTIFF'S CLAIM NOT UPHELD BY COURT

The plaintiff asserted that there was only \$200 of cash paid in, no tangibles remaining after 1913, no surplus "used and employed" in the business, and that the secret process was an "intangible" which must be taken at its "actual cash value" in April, 1909, which was shown to be nothing. The defendant argued that the sums spent upon the process, which did in fact increase its value by \$19,000, should be taken as a surplus "used and employed" in the business.

The federal court in passing on this case held that the increased value of a process resulting from expenditures thereon figures as asset in estimating "earned surplus." It said where the only asset of a corporation was a secret process, which was intangible and of no value in April, 1909, the date on which the actual value of intangible assets was to be determined under the revenue law, but thereafter money was expended in developing the process, so that in 1917 the company had a surplus above its capital stock which was its only liability, the increased value of the process, due to the expenditures thereon, is to be considered as "earned surplus" which under the revenue law of 1917, section 207, is an element of invested capital, in determining whether the corporation had more than a nominal invested capital under section 209, though the increased value of the process due to the war could not be so considered.

The court found that the chemical company failed to prove that its value in 1917 over \$10,000 was "not more than nominal." Hence for failure of proof judgment was rendered against it.

Germany's Potash Production, January-June, 1921

The German Potash Syndicate's semi-annual statement shows that the German potash production during the first 6 months of 1921 came to 4,454,261 metric tons of salts, or 497,373 metric tons of K_2O . This is equivalent to 548,105 short tons of actual potash. Sales during the same period amounted to 1,546,353 metric tons of salts, or 366,633 metric tons (404,030 short tons) K_2O , of which 1,408,911 metric tons of salts, or 333,281 metric tons (367,276 short tons) were for domestic use.

The Beet-Sugar Industry in the U. S. in 1920*

By C. O. TOWNSEND

Pathologist in Charge, Office of Sugar-Plant Investigations

IN THE United States in 1919, 98 beet-sugar mills were standing and equipped for extracting and refining sugar from beet roots. The oldest one of the mills now standing was built in 1870 at Alvarado, Cal. During the summer of 1919, 4 of the 98 mills had been erected and equipped for the campaign of 1919-20, 6



FIG. 1. LOCATION OF BEET-SUGAR MILLS

Dots indicate that the mill was in operation during the 1920-21 campaign. Mills that were standing idle are indicated by crosses.

additional ones were built and equipped for the handling of the 1920-21 crop, and 2 others are in process of construction, making a total of 106 beet-sugar mills now standing.

During the past 50 years 5 other mills have been built, but 3 of them have burned, 1 has been dismantled and 1 has been utilized for some purpose other than that of making beet sugar. Of the 106 beet-sugar mills now standing (Fig. 1), 26 were erected at some point other than the place where they are now located, but owing to certain limiting factors in beet-sugar production these 26 mills were removed to other locations; 2 of these were built in Canada and removed to the United States and 1 was built in this country and removed to Canada.

The 106 mills now standing are for the most part favorably situated for extracting and refining beet sugar under present conditions. In many instances certain limiting factors will need careful consideration and readjustment before a sufficient quantity of raw material can be assured annually to make all of them permanently successful. In many areas beet-sugar mills have been crowded in too rapidly, so that it has not been possible to readjust the farming operations and install the required drainage, irrigation and other improvements with sufficient rapidity to provide the necessary well-prepared acreage to supply enough sugar beets to insure a normal mill run. Consequently neither the mill

owners nor the growers have received under these conditions a maximum return for the money and labor invested.

The production of sugar from beets in the United States for the 5-year period from 1916 to 1920, inclusive, is shown in the accompanying table.

Combined Crucible Holder and Thermocouple

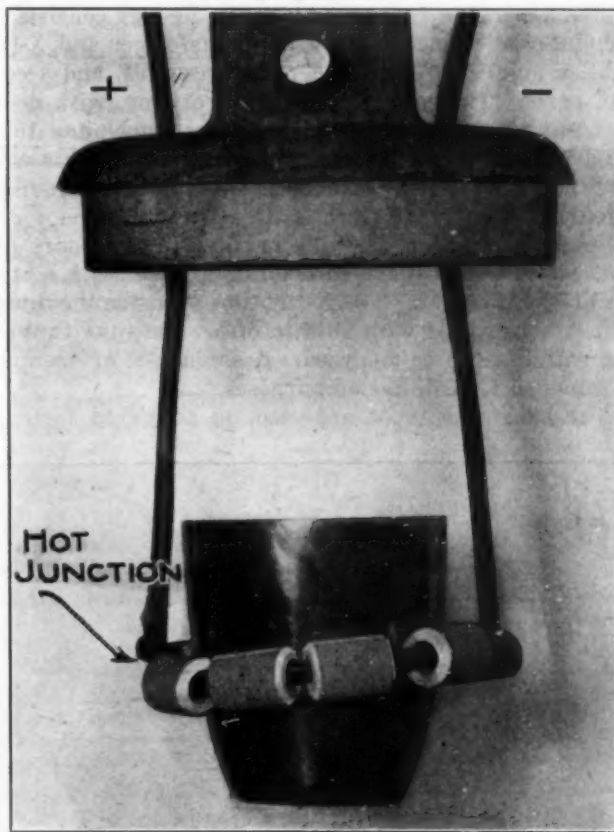
By CHARLES Y. CLAYTON

Professor of Metallurgy and Ore Dressing, Missouri School of Mines and Metallurgy

In "Standard Methods for Laboratory Sampling and Analysis of Coal," as published by the American Society for Testing Materials, the method for determining volatile matter is given as follows:

"Weigh 1 g. of the coal in a weighed 10 to 20 c.c. platinum crucible, close with a capsule cover, and place on platinum or nichrome-wire supports in the furnace chamber, which must be at a temperature of 950 deg. C. (± 20 deg. C.)."

The design of furnace as given on page 10 of the



CRUCIBLE HOLDER AND THERMOCOUPLE

pamphlet shows an especially constructed furnace with thermocouple inserted through the bottom.

Wishing to utilize an ordinary crucible type furnace (nichrome resistor) the idea was conceived that if the crucible support was made of two dissimilar metals, the temperature of the furnace could be determined

*Abstract of Bulletin 995, Department of Agriculture.

BEET-SUGAR PRODUCTION, 1916 TO 1920

Year	No. of Sugar Mills	Days Operating	Beets Harvested, Acres	Beets Produced—		Extraction, per Cent	Average Sugar in Beets, per Cent		Coefficient of Purity	Sugar Made, Tons	Price Paid for Beets	
				Average per Acre, Tons	Total Tons						Average per Ton	Total
1916.....	74	80	665,308	9.36	6,228,256	13.86	16.30	84.74	820,657	6.12	38,139,000	
1917.....	91	74	664,797	9.00	5,980,377	13.60	16.28	83.89	765,207	7.39	44,192,000	
1918.....	89	81	594,010	10.01	5,948,798	13.64	16.18	84.70	760,950	10.00	59,494,000	
1919.....	89	78	692,455	9.27	6,421,478	12.34	14.48	82.84	726,451	11.74	75,420,000	
1920.....	97	91	872,376	9.80	8,546,193	13.63	15.99	83.97	1,090,021	11.63	99,426,000	

without the use of a special furnace, with thermocouple entering through the bottom. The photograph shows the crucible support and thermocouple as designed by the writer for the use of the students in the Missouri School of Mines and Metallurgy. By drilling two holes in any furnace cover and inserting the two dissimilar wires any electrically heated crucible type furnace can be used for this determination.

By using a slightly different design of thermocouple and support, a very similar arrangement can be used for the heat-treating of small steel samples in the laboratory. Using this in conjunction with a recording potentiometer, a heating curve can be obtained showing the transformation point, and no calibration of the thermocouple is necessary.

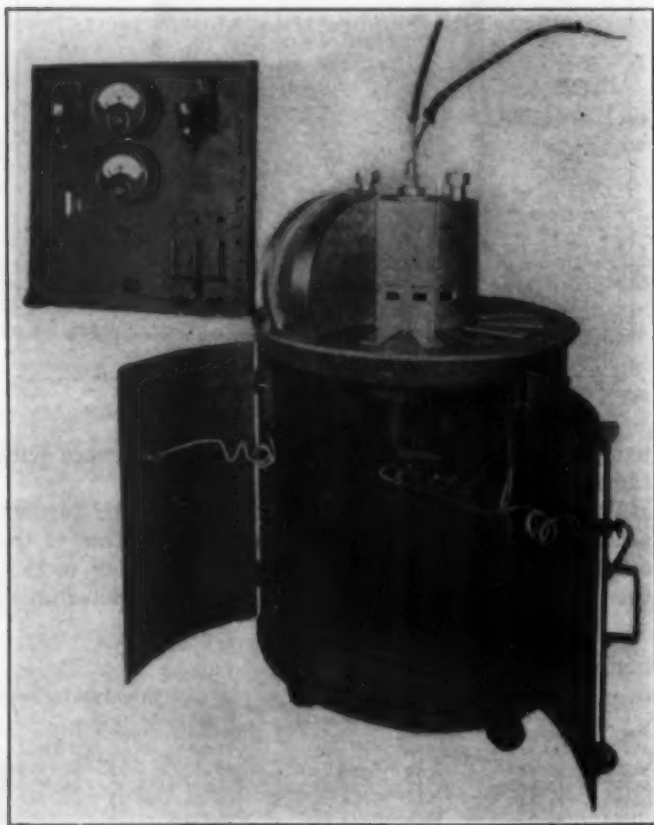
Rolla, Mo.

X-Ray Diffraction Apparatus for Crystal Analysis

Apparatus for X-ray studies of crystal structure according to the method outlined by Edgar C. Bain in this journal Oct. 5, 1921, p. 657, has been developed by the research laboratory of the General Electric Co.

The apparatus (see accompanying figure) consists of a cylindrical case containing the transformer and X-ray tube, a number of film holders, or cassettes, and a control panel. The case is made of sheet iron, with doors in front to permit access to the transformer and tube. To avoid the possibility of accidents from contacts with live parts when the case doors are open, the supply circuit of the transformer is brought across the doors, so that it must be disconnected before the doors are opened. The top of the case forms a table, with a steel tower in the center. The X-ray tube is inside the tower, which is provided with slits to direct the rays through the substance to be analyzed. A second set of openings is provided for calibration purposes.

The substance to be analyzed, in powdered form, is



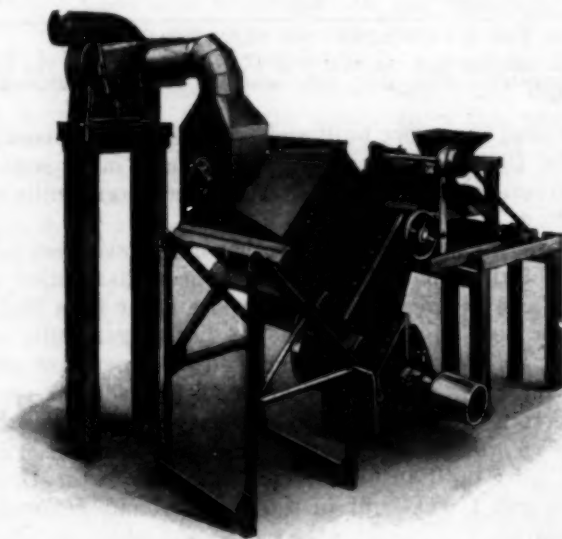
X-RAY DIFFRACTION APPARATUS

inclosed in a small tube of special glass held in the cassette in a horizontal plane by spring clips. The cassettes, or film holders, slide on guides on the table, fitting against the tower so that their glass tubes holding the specimens are in the path of the X-ray beam through the slit system. Rays passing through the substance are diffracted and register characteristic lines on the film which fits into the back of the holder.

The X-ray tube gives off molybdenum characteristic rays, of such long wave length that $\frac{1}{4}$ -in. iron or brass provides enough protection, and no lead is necessary. The tube is water-cooled; to prevent its running too hot, in case something happens to the water supply, a pressure-stat on the control board trips the breakers whenever the water pressure drops below normal.

The Pulverburner

The Pulverburner is a new machine for the preparation of powdered coal which has recently been placed on the market by the K-B Pulverizer Co., Inc., New York. The essential features of the machine are the pulverizing mechanism and the air-separating chamber. It will be seen from the accompanying illustration that the machine is fed by an automatic feeder of the belt



EXTERIOR VIEW OF PULVERBURNER

type. The pulverizing is accomplished by means of six rapidly revolving hinged beaters which smash the coal against breaking blocks and then against grinding plates in the bottom of the machine. The pulverulent material is discharged by centrifugal force directly into a large separating chamber. An exhaust fan, in the discharge duct leading from the separating chamber, induces air at slow velocity through the chamber, removing the fine coal and permitting the oversize to return to the machine for further pulverization. It is apparent that the velocity of the air through the separating chamber determines the fineness of the product. From the separating chamber the fine dust is drawn through the fan and blown directly into the furnace. Secondary air is added at the nozzle. By using "splitters" the stream of coal and air can be distributed to several nozzles, thus enabling one machine to serve several furnaces.

By combining impact pulverization with air separation many advantageous features are obtained. The

finer is removed from the machine as rapidly as produced so that the beaters are always operating on coarse material. This is an important item of power saving, even though impact pulverizing is known for its low power requirements. Coal that has not been dried can be successfully handled in this type of mill, and because of the air separator there are no screens to clog.

For efficient powdered coal burning close regulation is necessary, and this has been provided for in the Pulver-burner. The rate at which the coal is fed is controlled by the automatic feeder by means of a cam arrangement that varies the speed of the belt. (The coal should be fed in such a size that a uniform "ribbon" is formed on the belt. Coal of 1 in. and under is satisfactory.) A magnetic pulley can be used with the feeder to prevent tramp iron from entering the machine. Quantity of air is controlled either by the speed of the fan, if a variable speed motor be used, or by a damper in the discharge passage. Air is introduced around the shaft. Velocity of the air through the separating chamber is regulated by two vanes in the chamber controlled through a worm and wheel. The beaters can be extended radially outward as they wear. The entire controlling mechanism can be operated by an automatic regulator.

The apparatus is designed to be driven by one, two or three motors. If one motor is used, both fan and feeder are driven from the pulverizer shaft. It is sometimes desirable to drive the fan from a separate motor, likewise the feeder.

The advantages claimed for the machine are its compactness, close regulation of fineness and air, simplicity, economy and adaptability to small as well as to large installations. It is being built in capacities up to 3 tons per hour.

Book Reviews

THE DESTRUCTION OF THE FRENCH METALLURGICAL PLANTS BY THE GERMANS (NOS USINES MÉTALLURGIQUES DÉVASTÉES) 1914-1918. Monograph edited by a group of engineers, with an introduction by Prof. Léon Guillet. Published, 1921, by *Revue de Métallurgie*. xxxiii + 270 pp. in quarto, with 300 illustrations. Price, 26 f.

In the introduction to the monograph *Nos Mines Métallurgiques Dévastées* Prof. Guillet discusses the industrial importance of the French invaded region when compared with the similarly important regions of England (Lancashire, Chester, Derby, Leicester, Nottingham, Stafford and part of York) and of the United States (Pennsylvania, Ohio, West Virginia and the states bordering the Atlantic from New Jersey to Florida) and gives a series of tables and maps showing the pre-war and war-time production of the French metallurgical plants.

The plan followed in the monograph is to give brief outlines of the history and pre-war importance of the plants and illustrative descriptions of their destruction. The plants described are:

Steel plants of the Denain & Anzin Co., by Robert Jordan (pp. 1-30); zinc plants of Noyelles-Godault, by E. Demenge (pp. 31-40); Denain plants of the Soc. Française de Constructions Mécaniques, by L. Decroix (pp. 41-48); aluminum plants of Mennesis (pp. 49-52); Homécourt plant, by Paul Thomas (pp. 53-63); Douai plant of the Etablissements Arbel, by Alfred Brochard (pp. 64-77); Joeuf plants of the Etablissements De Wendel & Cie., by Jean Durand (pp. 78-88). Ferrière-La-Grande plants of the Etablissements Delattre & Frouard, by M. Lhonneur

(pp. 89-98); plants of Biache-Saint-Vaast (pp. 99-112); plants of the Micheville Steel Co., by Paul Nicou (pp. 113-130); plants of Mont-St.-Martin of the Longwy Steel Co., by F. Meyer (pp. 131-150); Rehon plant of Soc. de la Providence, by P. German (pp. 151-160); Aulnoye plants of the Soc. Métallurgique de Montbard-Aulnoye, by P. Jarry (pp. 161-166); Senelle plant of the Senelle-Maubeuge Metallurgical Co., by Henri Lallement (pp. 167-180); plants of Vireux-Molhain, by M. Linard (pp. 181-188); plants of the Forges et Aciéries du Nord et de L'Est, by F. Villain (pp. 189-204); plants of Givet of the Cie. Française des Métaux, by A. Mercier des Rochettes (pp. 205-220), and the plants of the Franco-Belgian Metallurgical Co. of Mortagne, by M. Maréchal (pp. 221-226).

Loose-leaf indexes of the illustrations in English, Spanish and Italian accompany the text.

A similar book has been published by the Société d'Encouragement pour l'Industrie Nationale, which is a reprint of an article by L. Baclé in the November-December, 1920, issue of the society's bulletin. In this book of 101 pages and 100 photographic views are described, in addition to some of the plants enumerated above, also those of Louvroil (Sté. Ame. de l'Espérance), Wrangles (Sté. Métallurgique de Pont à Vendrin), Gorcy (Soc. Métallurgique de Gorcy) and Auboué (Soc. de Pont-à-Mousson). J. S. NEGRU.

* * *

THE CHEMICAL ANALYSIS OF STEEL - WORKS MATERIALS. By Fred Ibbotson, B.Sc., F.R.C., Sc.I., F.I.C. Pp. viii + 296. New York: Longmans, Green & Co., 1920. Price, \$7.50.

This volume is a revision of "The Analysis of Steel-Works Materials," that was published under the joint authorship of Harry Brearley and Fred Ibbotson in 1902. The revision covers that part of the last-named book that treated of the analysis of the raw materials and the finished steel.

The book is divided into eight parts, including (1) General Processes and Notes. (2) Pig Iron and Steel. (3) The Analysis of Steel-Making Alloys. (4) Ores. (5) Refractories. (6) Slags. (7) Analysis of Fuels. (8) Boiler Water and Boiler Scale.

The book is well written and the methods are described in full detail. A most complete account of the reactions involved is to be found throughout the entire work. This is a valuable feature for students. However, some statements concerning methods need qualifications. For instance, the statement found on page 127 that "the determination of cobalt by the cyanometric method is of little or no value" is contrary to the facts. For it has been demonstrated that by the use of tartaric to keep the iron from precipitating in ammoniacal solution, and by always having at least 1 g. of iron present per 0.1 g. of Co, then cobalt can be determined in steel with the most satisfying accuracy up to 10 per cent. Cobalt steels never contain over 6 per cent and seldom over 5 per cent Co. This cyanometric method has been in continuous use in the United States for at least 13 years in some laboratories, and is to be preferred for speed, simplicity and reliability.

Certain methods and apparatus could well be omitted as obsolete, such as the determination of carbon by direct wet combustion and Geissler bulbs for weighing CO₂. The unwary beginner might try these and be severely discouraged with the art. But no doubt this is part of the author's scheme of giving some of the history of human progress in iron and steel analysis in its different phases.

A needless time-consuming detail, which is, also, still to be found in books by one or two other authors on iron analysis, is the recommendation given on page 142: Molybdenum is precipitated away from iron by saturating the solution with hydrogen sulphide. The "gassed" solution is then transferred to a pressure bottle; the latter is tightly stoppered and kept in boiling water for an hour. Yet on page 144 the author says that this boiling digestion under pressure is usually unnecessary in steel. Why give it at all then? For the fact is that it is always unnecessary. It would be better to emphasize the all-important detail in precipitating Mo by hydrogen to have the solution contain as little free acid as possible before passing any of the precipitant through it.

The author on page 57 outlines twelve different ways of

estimating phosphorus, and on the next page gives a thirteenth method which is described in detail. "An experienced operator can make thirty tests in a 7-hour day." The method is by "weighing as lead molybdate."

In the list of methods for manganese no space is given to the ancient and still honorable oxidation to permanganic acid by lead peroxide, which, when properly carried out, has the widest range accuracy of any of the methods up to at least 16 per cent of Mn.

On page 121 the use of a condensing lens is still advised to aid in the cyanometric titration of nickel in alkaline citrate solution, whereas this was made entirely avoidable 14 years ago (see *J. Am. Chem. Soc.*, vol. 29, No. 8, August, 1907) by the simple expedient of adding 12 g. of citric acid instead of 3 g. per gram of steel. The magic lantern detail should be omitted, as it was but little help at best.

In describing the determination of carbon by combustion one would expect to find an illustration showing an electrically heated combustion furnace with a modern purification and absorption train, but a gas furnace only is shown with a verbal account of the accompanying train. Mention is made that electric furnaces are used.

This work contains much excellent information and no iron and steel analyst can afford to have it absent from his ready reference shelf, even though it already be a 5-ft. one or a 10-ft. one.

C. M. JOHNSON.

AN INTRODUCTION TO THE PSYCHOLOGICAL PROBLEMS OF INDUSTRY. By *Frank Watts*. 240 pp. New York: The Macmillan Co., 1921. Price \$5.

This book by the lecturer in psychology in the University of Manchester and in the department of industrial administration, Manchester College of Technology, is the most interesting contribution to the literature of this subject that has recently appeared.

Perhaps the thing that Englishmen do best, as compared with American writers, is the discussing of a subject in a thorough and well-rounded manner, and yet in an interesting way. American writers are fluent in the production of literature on the details of a subject, but when it comes to a well-rounded summary on a whole topic, very often the best treatise is found to be by an Englishman. It is certainly true in this case, and is correspondingly curious, inasmuch as although study of the psychological problems of industry began first in this country and has been carried on by an immensely greater number of people here the best book on the subject now comes to us from England.

The reviewer is inclined to suspect that the author has probably a much more thorough acquaintance with industry than the American psychologists who write on this topic, and of course a good deal of the American literature has come from the pens of persons who are familiar with industry but who have a rather imperfect knowledge of psychology. At any rate, anyone who is interested in getting a reasonable grasp of the new viewpoint of the importance of mental problems in industrial life cannot do better than to read this book.

Evidently the author has been in fairly close touch with the work of the Industrial Fatigue Research Board, for his book begins with a discussion of industrial fatigue and inefficiency, and the first section of Chapter II deals with muscular fatigue. The second section is on organic variability, and the third section on mental fatigue. This section indicates the thoroughness of the study and how well balanced the author is, for fatigue investigators generally have continued to overlook the importance of mental fatigue in the study of the problem, although even the laboratory investigators know that if the subjects have worked an ergograph to the point of exhaustion and are then told that with the removal of a pound weight they can continue to work, but instead a pound weight is added, they will go on working just as happily as though the pound weight had actually been removed. There are those in this country who believe that mental aspects of industrial problems far outshadow the importance of those physiological aspects that have heretofore received practically all of the intensive study that has been given to the subject.

The third chapter deals with the elimination of fatigue

from work by motion study, and is a good brief review of the work done on this topic. The chapter on vocational education is also good, and this is especially true of the third section, which deals with intelligence tests, and the criticisms which are made of the application of intelligence tests to industrial life are both temperate and apparently entirely sound. The chapter on scientific management and labor is perhaps the best in the book, and is an extremely interesting summary of the abundant literature on this subject. The chapter on industrial unrest similarly summarizes, in a brief and readable way, the rather abundant literature that to most operating men would seem so vague and far from their immediate problems as to be unattractive to them. When all these ideas are brought together, in their relation to one another, and concisely summarized, their importance and usefulness becomes apparent. The concluding chapter deals with the creative impulse in industry and deals with such apparently diffuse sub-topics as the decline of the traditional types of craftsmanship, modern recreation, ideals in industry, copartnership, state socialism, syndicalism, industrial democracy and industrial education. The author has brought these together, however, so that their bearing on one another becomes apparent. In other words, he has proceeded in his book from the central core of his subject out to the periphery. Each chapter is supplemented by a brief list of the more important works on the topic, which will be extremely valuable to those who care to pursue any of the topics further. Altogether, this is a most satisfactory book, and one that ought to be not merely in the library of anyone interested in industrial work, but kept at hand where it is easily available for re-reading from time to time.

T. T. READ.

Recent Chemical & Metallurgical Patents

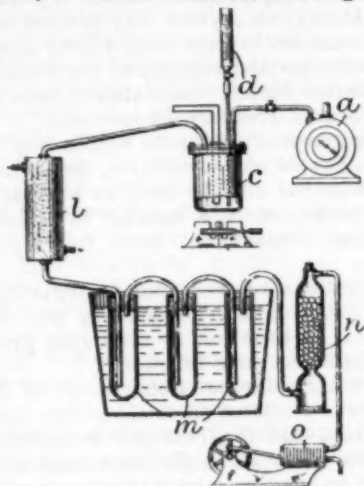
British Patents

For complete specifications of any British patent apply to the Superintendent, British Patent Office, Southampton Buildings, Chancery Lane, London, England.

Colloidal Elements and Compounds.—Colloidal solutions of copper, silver, mercury, cerium, arsenic and antimony, or of their insoluble compounds, are prepared by treating these metals or their compounds for some time at temperatures above 100 deg. C. with waste sulphite cellulose liquor or waste soda cellulose liquor. The metal or its insoluble compound in the powder form may comprise the starting material; or a soluble salt of the metal may be added to the cellulose waste liquor and the metal or its insoluble compound formed therein during the process either by the addition of precipitants, such as alkali, or by the reducing action of the cellulose waste liquor itself, with or without other reducing agents, such as sulphuretted hydrogen. The colloidal product may be precipitated or purified in any known manner and utilized in medicine, veterinary surgery, tanning, the preparation of cosmetics, for the protection of plants and the impregnation of wood or fabric. The colloidal products may be employed per se, or in conjunction with oil, resin, and other organic emulsions, or with the addition of colloids or filling substances. In the case of plant protection, such materials as aluminum hydrate, aluminum sulphate, gypsum, barium carbonate, lime or copper-lime mixtures may be added to the colloidal products. According to the examples: (1) Colloidal mercury is prepared by heating mercuric chloride with purified waste sulphite cellulose liquor; preferably with addition of caustic soda or potash; or by heating mercuric oxide with the lignine substances extracted from waste sulphite cellulose liquor in the known way; (2) copper sulphate, on heating with waste sulphite cellulose liquor and soda lye, is converted first into colloidal copper protoxide and then into colloidal copper; a similar result is obtained by heating powdered copper oxide with a mixture of waste soda cel-

lulose liquor and waste sulphite cellulose liquor; (3) colloidal silver is obtained by the heat-treatment of silver oxide with waste sulphite cellulose liquor; (4) colloidal sulphide of arsenic results from the introduction of sulphuretted hydrogen into a hot solution of arsenious acid in cellulose waste liquor. (Br. Pat. 169,758. Chemische Fabriken Dr. K. Albert und L. Berend, Amöneburg, near Biebrich, Germany. Nov. 23, 1921.)

Concentrating Ores.—Reagents for use in concentrating ores by froth flotation are obtained by subjecting organic substances to a partially decomposing heat in the presence of air or oxygen. The organic substances treated may be liquids or solids—for example, kerosene, gas oil, bitumen, bituminous coal, wood or mineral-frothing agents such



as oleic acid or cottonseed oil—and the oily or aqueous condensates or gaseous or vaporous distillates of the decomposition may be used in the flotation process. In the apparatus shown in the figure, for the treatment of liquids, the material to be treated is fed from a burette *d* to a heated chamber *c* to which a regulated supply of air is admitted from a meter *a*. The products are drawn by a pump *o* through condensors *l*, *m* and a scrubber *n*. In some cases the condensors may be omitted and the products passed direct to the flotation apparatus. Apparatus for treating solids may comprise a heated retort or chamber for a charge of material and a system of condensors, etc., similar to that shown in the figure. In another case, refractory material saturated with kerosene may be treated by igniting the kerosene, sucking air through it and passing the products to the flotation apparatus. (Br. Pat. 169,288. Minerals Separation, Ltd., London; E. W. Wilkinson, New York. Nov. 9, 1921.)

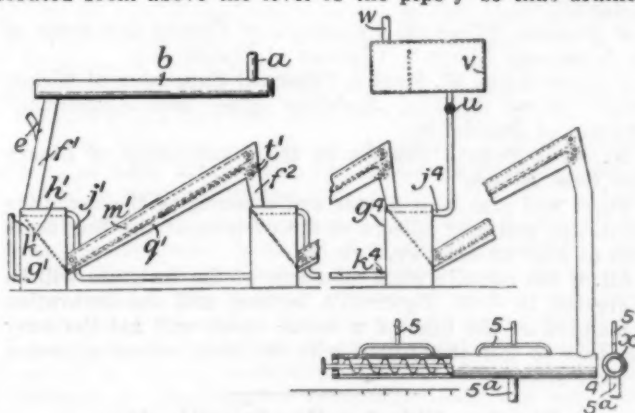
Resinous Compounds; Shellac Substitute.—A substitute for shellac consists of spirit copal, preferably Manila or Macassar copal, with 6 to 8 per cent of oleic acid, preferably in the form of Australian oleine; candelilla wax, resin and dyes are added to give imitations of different varieties of shellac. The materials are melted and stirred together for 2 hours in a steam-jacketed vessel, and then poured out and passed between rollers, which may be indented to form "buttons." The rollers may be cooled. (Br. Pat. 169,829. E. A. Muskett, Enfield, Middlesex. Nov. 23, 1921.)

Treatment of Aluminum Alloys.—To prevent surface corrosion, aluminum alloys in which aluminum predominates, and particularly those containing copper, manganese, and magnesium, are first boiled in an alkaline solution, such as of caustic soda, then treated in a steam bath, then immersed in a solution of zinc phosphate containing iron phosphate in suspension and of gradually increasing temperature, and finally washed in hot water. The first step may be effected in a water-jacketed porcelain vessel heated to 160 to 180 deg. F., the article being boiled in a caustic soda solution of $\frac{1}{2}$ per cent strength for about 20 minutes until a black oxide is formed. Preferably the vessel is heated in a gas oven with a ventilating flue so that the article can be quickly dried on withdrawal from the solution with the aid if necessary of a warm jet of compressed air. The article is then suspended in a steam bath for a

few minutes only until the coating becomes greenish yellow. Ammonia in small regulated quantity is introduced to prevent acidity during the steaming. A paste formed by the treatment of granular zinc with specified proportions of orthophosphoric acid and boiling water is dissolved in water, 1 oz. to 1 gal., and the solution is boiled in an iron tank for a few hours daily with small additions of the paste, pieces of scrap iron or steel being suspended in the solution. Equal parts of the residual liquor and cold water, with a small quantity of a saturated solution of the paste, form the phosphate solution into which the article is immersed direct from the steaming for 10 to 15 minutes. The coating changes in color to gray and finally pink, if the solution becomes stronger, and when all the yellow has disappeared the article is washed. (Br. Pat. W. B. Bruns-kill, Cark-in-Cartmel, Lancashire. Nov. 23, 1921.)

Dyeing Cellulose Acetates.—For the purpose of rendering them amenable to dyeing, threads or fabrics containing cellulose acetates having 2-2½ acetyl groups per cellulose molecule are treated, at temperatures between 40 and 80 deg. C., with an alkaline saponifying agent, the quantity of which is restricted to that necessary to produce a diminution in weight of not more than 10 per cent in the cellulose acetate originally present. The saponification treatment may precede the dyeing operation, or they may be performed together in the same bath. As saponifying agent, caustic soda, caustic potash or carbonate of soda may be employed, in concentration not greater than 1 per cent; any dyes, such as substantive, acid, basic, vat or sulphur dyes, are applicable, either directly or with the use of mordants. The provisional specification includes the treatment of any cellulose acetate lower than the triacetate and states that the restricted saponification may also be effected by using excess saponifying agent and limiting the time of action thereof. (Br. Pat. 169,741. British Cellulose & Chemical Manufacturing Co., Ltd., London, and J. F. Briggs, Spon-don, near Derby. Nov. 23, 1921.)

Extracting Fats.—In a counter-current process for the extraction of oils, etc., from crushed seed or other vegetable matter by means of volatile solvent and in which solvent is expressed from the mass after each immersion, the meal from a pipe *a* is conveyed through a jacketed conduit *b* and falls on to a preferably inclined screen *k* in a tank *g* so that its progress is retarded while it mixes with used solvent from a pipe *j*. The meal is then conveyed to wringing rollers *t* through a conduit *m* having its bottom perforated from above the level of the pipe *j* so that drained



or expressed solvent runs down an outer conduit *q* to the tank *g* but below the screen *k*. The pressed meal falls down a conduit *f* and is passed through a series of similar tanks, conduits and rollers to a perforated conduit *x* in which it is freed from solvent by steam or vapor from a pipe *5a* in the lower half of a divided jacket *4*, the vapors being drawn off to a condenser through pipes *5*. Pure solvent is fed from the tank *v* to the last tank *g* by a valve *u* and pipe *j* and through the series by pipes *k* and *j* to the last outlet pipe *k*, which leads to a solvent-recovery apparatus. The recovered solvent is returned to the tank *v* by a pipe *w*. Solvent vapor in the tank *g* or pipe *f* is drawn to the recovery apparatus through pipe *e*. (Br. Pat. 169,738. M. Whitehead and E. Scott, both in Kingston-upon-Hull. Nov. 23, 1921.)

Technical News of the Week

Current Events in the Chemical, Metallurgical and Allied Industrial Fields—Legislative Developments—Activities of Government Bureaus, Technical Societies and Trade Associations

Well-Known Glass Manufacturer Probable Ambassador to Germany

The nomination of Representative A. B. Houghton, of New York, to be Ambassador to Germany probably will be sent to the Senate this week by President Harding.

Mr. Houghton has been associated with the Corning Glass Works since 1889, serving as second vice-president from 1903 to 1910, as president from 1910 to 1918 and is now chairman of the board of directors. He is also vice-president of the Ephriam Creek Coal & Coke Co. and a director of the Metropolitan Life Insurance Co.

Program for February Meeting of Institute of Metals Division

Following is the preliminary announcement of the forthcoming session of the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers, held in connection with the February meeting in New York:

Monday, Feb. 20, 2 p. m. Chairman, W. H. Bassett.

E. E. Thum, "Results Achieved by the Corrosion Committee of the British Institute of Metals."

R. J. McKay, "Corrosion by Electrolytic Concentration Cells."

L. McCulloch, "Experiments With Sherardizing."

W. H. Bassett and C. W. Davis, "Spectrum Analysis in an Industrial Laboratory."

H. J. Roast, "Arsenic-Bearing Metals."

Tuesday, Feb. 21, 10:45 a.m.

First annual lecture of the Institute of Metals Division, Prof. Wilder D. Bancroft, "Colloid Chemistry and Metallurgy."

Tuesday, Feb. 21, 2 p.m., Chairman, W. H. Bassett.

Z. Jeffries and R. S. Archer, "The Slip Interference Theory of the Hardening of Metals."

E. C. Bain, "Crystal Structure of Solid Solution by X-Rays."

P. Hidnert, "Thermal Expansion of Copper and Some of Its Important Alloys," (Bureau of Standards.)

P. Hidnert and W. Souder, "Thermal Expansion of Nickel, Monel Metal, Stellite, Stainless Steel and Aluminum," (Bureau of Standards.)

W. McG. Peirce, "Studies on the Constitution of Binary Zinc Base Alloys."

There will also be a dinner and meeting of the executive committee and past officers of the division at the Engineers Club at 5:30 on Monday, Feb. 20.

All of the metallurgical members of the Institute will be interested in Prof. Bancroft's lecture, and the innovation is planned as the first of a series which will aid the busy members to get acquainted with the most recent advances in their science.

Senators Sidestep Dye Investigation

Senator Borah of Idaho has found that it will be impossible for him to devote the time likely to be required as a member of the sub-committee which will conduct the dye investigation recently ordered by the Senate. Nearly every member of the Judiciary Committee has been urged to accept service on this sub-committee, but all have declined, since they foresee that this investigation will be of long duration and will require a great deal of their time. While there is still hope that some member of the committee can be induced to accept this service, it is probable that some delay will result before the sub-committee can be completed. Senator Shortridge of California has accepted the appointment as chairman of the sub-committee and Senator Reed has consented to represent the minority on the committee.

Study of Plant Depreciation Planned by U. S. Chamber of Commerce

Practical studies by the various industries to ascertain a normal rate of depreciation shown by experience on buildings, machinery, etc., which may be used as a basis for reckoning depreciation in individual plants is urged by the Fabricated Production Department of the Chamber of Commerce of the United States. Such studies have the approval of the United States Treasury Department.

It is not the purpose to create within any industry inflexible standard rates of depreciation, but it is proposed to set up something that may be used as a guide to fit usual conditions, as explained in a bulletin in which the Fabricated Production Department puts forward its recommendation.

"Trade associations representing a single line of industry," says the bulletin, "are particularly well fitted to take up such studies. In lines not so organized groups may be formed to perform the same function."

The Fabricated Production Department of the National Chamber has been working on this problem for some time. The announcement that the Treasury Department approves investigation and study along the lines suggested will be of unusual interest to business men, particularly manufacturers.

Additional information may be obtained from the Fabricated Production Department of the Chamber of Commerce of the United States.

New Muscle Shoals Proposal Submitted by Shipbuilder

A new proposal for leasing and operating the Muscle Shoals plants has been received by Secretary Weeks from Frederick E. Engstrum, president of the Newport Shipbuilding Co.

Mr. Engstrum proposes to form a corporation which will guarantee (under bond) to complete the power stations, dams Nos. 2 and 3 and such other works as may be agreed upon, and to lease the property for a period of 50 years. Construction will be started within 60 days from date of possession and completed within 4 years.

Excess power would be sold by the company at a minimum price of 1 mill per kw.-hr. It is proposed to operate the nitrate plants by diverting to this purpose the net receipts, up to and including 1 mill per kw.-hr., from the sale of the excess power, over and above that required to operate the property, in addition to the gross receipts from the sale of the nitrate products (at prices and terms to be fixed by the government). At least one of the nitrate plants would be put in operation within 1 year from date of possession. A research department would also be maintained in co-operation with the government for the purpose of developing the processes for nitrogen fixation.

In consideration of the performance of these proposals the government would agree to pay to the power company \$36,000,000, in four equal annual installments. All of the proceeds from the sale of power in excess of 1 mill per kw.-hr. would be retained by the power company as its compensation for the undertaking of this proposal.

Miniature Experimental Tannery Built at Columbia University

What is said to be the smallest complete tannery in the world has recently been completed at Columbia University, New York, under the direction of Prof. A. W. Thomas. The tannery is about 2½ ft. long and was designed to handle raw hides under a scientific tanning process. The purpose of the plant is to provide means for a careful and scientific study of the chemical action of tanning.

Biscuit and Cracker Manufacturers' Association Appoints New Director

As a step in the development of the Technical Bureau of the Biscuit and Cracker Manufacturers' Association, the technical committee has been authorized to obtain the services of A. V. H. Mory, well known for his success in the organization and direction of industrial laboratories. Mr. Mory's experience has been broad rather than special, but has been largely in food lines. Entering the employ of Armour & Co. as a chemist, he became head of the chemical department of that company's Kansas City plant. He later entered the Bureau of Chemistry at Washington and was appointed chief of the government's food and drug inspection laboratory at Kansas City, Mo. While in government service he was invited by Sears, Roebuck & Co. to develop an organization for the technical control of their whole line of merchandise and served there for 9 years as director of their technical laboratories. Two years ago he was invited by Procter & Gamble to reorganize and become executive head of the greatly enlarged chemical division then planned by them, but a short time ago he returned to Chicago to engage in consulting practice, specializing in organization work of the sort he is undertaking for the Biscuit and Cracker Manufacturers' Association.

Mr. Mory was chairman of the Chicago Section of the American Chemical Society in 1916 and later one of the society's councilors at large. For a number of years he has been on the editorial advisory board of the *Journal of Industrial and Engineering Chemistry*. He is a member of the Chemists' clubs of New York and Chicago and enjoys wide acquaintance in food control circles.

Improved Business Conditions Indicated by Increased Operations of Plants

Paper. The Northern Paper Mill, Green Bay, Wis., is operating its plant at full capacity and has added about fifty operatives to the normal working force. All six machines at the mill are on a day and night schedule.

Glass. The Owens Bottle Co., South Glassboro, N. J., has established operations with full working shifts and purposes to continue production throughout the winter season.

A number of idle glass plants in the vicinity of Millville, Vineland and Bridgeton, N. J., are preparing for the early resumption of operations.

The three window glass manufacturing plants at Kane, Pa., are arranging for a continuance of production throughout the winter season, these being the American Window Glass Co., Pennsylvania Window Glass Co. and the Kane Glass Co. The plants are giving employment to a total of about 1,000 operatives.

Ceramic. The Fords Porcelain Works, Perth Amboy, N. J., manufacturer of sanitary ware, is operating its three local plants at full capacity.

The Perth Amboy Tile Works, Perth Amboy, N. J., manufacturer of floor tile and fine ceramics, is operating at capacity and has construction under way on an addition, to be placed in service as soon as completed.

Rubber. The B. F. Goodrich Co., Akron, Ohio, has added about 1,000 men to the working force at its tire-manufacturing plant during the past 3 weeks. Production is now in excess of 16,000 tires a day. The aeronautical department at the rubber mills is working at full capacity on government orders.

The Phoenix Rubber Co., Akron, Ohio, is planning to resume production at its local plant at an early date.

The Firestone Tire & Rubber Co., Akron, Ohio, is increasing the working hours at its plant. Additional workers have been added to the force.

Oil. The Francis Refining Co., Ada, Okla., has commenced operations at its new local oil refinery, and will run under a full-time schedule.

The Sinclair Refining Co. is arranging for the immediate resumption of operations at its refinery at Coffeyville, Kan. Reconstruction of a number of departments is now under way, involving improvements costing in excess of \$1,000,000.

Copper. A number of copper companies in the Butte, Mont., district are perfecting arrangements for a resumption of operations at their mines and reduction plants,

effective Jan. 16. The companies include the Anaconda Copper Mining Co., the Butte & Superior Mining Co., the Davis Daly Copper Co., the Tuolumne Copper Co. and the North Butte Mining Co. A wage reduction, based on a graduated scale approximately 50c. a shift, will go into effect at the time noted.

Iron. The McKinney Steel Co., Cleveland, Ohio, is arranging for the immediate resumption of operations at its Colby-Ironton iron mines, Bessemer, Mich., giving employment to about 500 men. The properties have been idle since last May.

The Charcoal Iron Co., Detroit, Mich., is making improvements at its mines in the Manistique, Mich., district, and proposes to place the plant in operation by Jan. 16. Effective early in January, the company will operate its Yale iron mines at Bessemer, Mich., under a day and night shift.

Steel. The Wickwire-Spencer Steel Co., Buffalo, N. Y., has increased production at its finishing mills to normal, or 100 per cent capacity.

Resumption of operations at the sheet mills of the Inland Steel Co. at Hammond, Ind., brings the company's production to 50 per cent capacity.

Zinc. The New Jersey Zinc Co., Palmerton, Pa., is increasing operations at its local works and it is expected that all departments will be running full, with regular working forces, at an early date.

Personal

Dr. JEROME ALEXANDER is now president of the Uniform Adhesive Company, Brooklyn, N. Y.

Dr. CHARLES BASKERVILLE, head of the department of chemistry, College of the City of New York, is seriously ill with pneumonia.

A. E. BUCHANAN, JR., formerly a member of the chemical department of E. I. du Pont de Nemours & Co., has assumed the duties of assistant editor on the staff of *CHEMICAL & METALLURGICAL ENGINEERING*.

S. G. BYAM, chief chemist at the Fairfield rubber works of E. I. du Pont de Nemours & Co., has resigned from that position to become chief chemist at the Plymouth Rubber Co., Canton, Mass., with entire charge of the technical development.

H. E. HANDY, who has been the metallurgist on the staff of the Washington Steel & Ordnance Co., has removed from Washington, as a result of the permanent closing of the plant and liquidation of this company's affairs. His new address is 773 Elmwood Ave., Providence, R. I.

H. T. HERRICK is with the American Aniline Products, Inc., at Lock Haven, Pa., and not Lock Haven, Conn., as stated in our issue of Dec. 21.

Dr. ERNEST FOX NICHOLS has resigned the presidency of the Massachusetts Institute of Technology and his resignation has been accepted by the executive committee of the corporation. His decision resulted from the unfavorable condition of his health. Dr. Elihu Thomson, of Swampscott, chief consulting engineer of the General Electric Co., who served as acting president after the death of President Richard C. Maclaurin in January, 1920, has again been appointed to that position.

WILLIAM RUSSEL, London representative of the Dorr Co., has recently made a professional trip to the Rand district of South Africa and is now in the Congo.

Dr. C. G. SCHLUEDERBERG of the Westinghouse Electric & Manufacturing Co. sailed on Jan. 7 for a trip to South America. He will visit points in Peru, Argentina, Chile and Brazil.

The newly elected officers of the American Chemical Society for 1922, are as follows: President, EDGAR F. SMITH; directors, M. C. WHITAKER and W. R. WHITNEY; councilors-at-large, A. M. COMEY, E. C. FRANKLIN, W. D. HARKINS and W. LEE LEWIS.

Market Conditions

IN CHEMICAL, METALLURGICAL AND ALLIED INDUSTRIES

A Survey of the Economic and Commercial Factors That Influence Trade in Chemicals and Related Commodities—Prevailing Prices and Market Letters From Principal Industrial Centers

Announcing a Weighted Index of Chemical Prices

In order to assist our readers in following the week-to-week fluctuations in the chemical market and also to provide a ready means of comparing the trend of these prices with those of other commodities, CHEMICAL & METALLURGICAL ENGINEERING has undertaken the compilation of a weekly index number for chemical prices. It is apparent that the simple average of the prices for a selected group of chemicals would be of little value, since it fails to take account of either the relative importance of the article or the proportionate increase or decrease in its price. In order to avoid these difficulties CHEM. & MET. has adopted a system of weighting based on production and imports.

The base of 100 to which these prices were compared was calculated on the average monthly wholesale prices for the year July 1, 1913, to June 30, 1914. These figures are identical with those prepared and used by the Chemicals Section of the War Industries Board in connection with its comprehensive studies of prices during the war.

HOW IT WAS OBTAINED

It is believed that a detailed explanation of how the weighted index number was obtained will be of some interest and at the same time will give a clearer idea of what the number means and how it may be used. In the first place, twenty-five commodities were selected on the basis of their importance as representing qualitatively and quantitatively the principal component branches of the chemical industry. These chemicals included in the index number are as follows: Acetic acid, citric acid, hydrochloric acid, nitric acid, sulphuric acid, ethyl alcohol, methyl alcohol, anhydrous ammonia, ammonium sulphate, barium chloride, bleaching powder, borax, caustic potash, caustic soda, copper sulphate, formaldehyde, glycerine, crude potassium carbonate, salt-cake, soda ash, crude sulphur, benzene, aniline oil, cottonseed oil and linseed oil.

The second step in the process was obtaining the statistics for the production and imports of each of these commodities for 1919. That year was selected primarily because of the completeness of the statistics compiled by the Census of Manufactures. A few of the articles included in the index are exported in considerable quantities, but these amounts were not taken into consideration, because it was intended that the index should represent total activity in the wholesale chemical market rather than merely the selling for consumption in this country.

The next step in the process consisted in multiplying the monthly prices by the commodity weights—i.e., the sum of the production and the imports. The sum of the figures thus obtained made up the total value of the year's business in these twenty-five chemicals, and from these data it was a comparatively simple matter to calculate a factor representing the relative importance of the separate commodities.

Finally, these war figures were compared with and expressed in terms of the pre-war base, which, as previously stated, was the average for the year ended June 30, 1914.

WHAT IT SHOWS

Wholesale prices of chemicals were not published in this magazine prior to 1917 and no effort is made in the present article to trace the trend of prices during the period 1914-1916. The monthly index numbers for the 5 years which have elapsed since that time are presented in the accompanying table. They show that during this period the chemical market has followed an unusually interesting course. From

191 in March, 1917, the index number had a gradual and consistent rise to 285 early in 1918. This high level of prices was maintained during almost the entire year, although immediately after the armistice, the cessation of the war-time demands and the lapse of the price control exercised by the government resulted in a noticeable decline in prices. The index number fell from 279 in November, 1918, to 227 in April, 1919. Shortly thereafter occurred the

CHEMICAL & METALLURGICAL ENGINEERING'S WEIGHTED INDEX OF CHEMICAL PRICES

Base = 100 for the year July 1, 1913, to June 30, 1914

	1917	1918	1919	1920	1921
January.....	198	281	262	242	181
February.....	195	285	250	252	166
March.....	191	281	233	252	157
April.....	207	286	231	261	140
May.....	222	267	227	279	143
June.....	222	272	229	274	147
July.....	233	277	231	274	148
August.....	240	278	251	264	158
September.....	252	278	272	267	147
October.....	264	280	233	263	151
November.....	265	279	239	240	147
December.....	283	277	245	189	145
Averages.....	212	279	242	255	152
Last week.....		143.30			
This week.....		144.49			

post-war boom during which the prices again rose almost to the levels reached in 1918. Unfortunately, however, our prosperity was short-lived. Beginning in October, 1920, there occurred one of the most precipitous declines of prices which history has ever recorded. The CHEM. & MET. index number fell off 74 points in 2 months and 123 in 6 months. In April, 1921, the prices of these chemicals stood at the lowest level noted during the 5 years. The remainder of 1921 saw only minor fluctuations in the chemical market, although by August the index number had risen to 158. From October and through the remainder of the year there has been a further, although very slow, decline. The past week, however, has been characterized by slight increase in prices, the index number showing a gain of 1.19 points.

Nation-Wide Reduction of Inventories Reported by Manufacturers

One of the outstanding features of the annual reports now being issued by manufacturers in every branch of industry is the emphasis placed on reduced stocks, both of raw materials and finished products. The national scope of this readjusting process has also been shown in an interesting manner by the Harvard University Committee on Economic Research. This committee points out that in July of this year the index for the volume of manufacturing reached its low point of 68.5 per cent of the average for 1919 and has since increased to about 90. The average for the first 10 months of 1921 was 79 per cent. On the other hand, car loadings for the first 44 weeks of this year are reported to be 94 per cent of the 1919 loadings during the corresponding period. Since car loadings serve as a direct index of goods distribution, it would appear that distribution has considerably exceeded production during 1921 and that therefore inventories must have been materially lessened.

Du Pont Dividend

A cash dividend of 5 per cent, or 25c., on both common and preferred stock has just been declared by the Du Pont Chemical Co. of Wilmington, Del. The dividend is payable Feb. 6 to stock of record Jan. 25.

Court Holds That Fusel Oil Is Not Subject to Import Control

The District of Columbia Court of Appeals on Jan. 3 upheld a decision of a lower court which had refused to restrain the Secretary of the Treasury from permitting large quantities of foreign fusel oil to enter the country in competition with butanol, which was alleged to be a similar product. Complaint had been brought by the Commercial Solvents Corporation of New York under the dye and chemical control section of the emergency tariff act.

The plaintiff contended that the Secretary of the Treasury had erred in declaring that fusel oil was not a synthetic organic chemical and therefore was not subject to the import control exercised over this class of chemical products. The judge refused to grant a temporary injunction to the butanol manufacturers and in doing so declared that he would not attempt to compare his technical knowledge with that of the Treasury Department experts. The question was clearly a matter of technical knowledge, the court held, and the judgment of the lower court was affirmed.

Is Calcium Carbide A Synthetic Organic Chemical?

The hearing of the claim of the British Cellulose & Chemical Manufacturing Co. to have calcium carbide included in the schedule of the safeguarding of industries act, which imposes a duty of 33½ per cent on the value of articles imported, was held in London on Dec. 22. The act requires all synthetic and organic substances to be in the schedule, and the point in dispute between the Cellulose company and the British importers of calcium carbide is as to whether this substance is organic or inorganic. It was stated in the course of a scientific argument that this question had never become acute until the present hearing.

Evidence in support of the case for the Cellulose company was continued. John Rogers, technical manager of Nobels Industries, Ltd., agreed with former witnesses that calcium carbide was synthetic and organic chemical. Matthew Dickie, general manager of the Cellulose company, said that at the request of the government his company erected a calcium carbide plant at a cost of £600,000. During 1919-20 the company was producing 19 tons of carbide per day. This was sold at that time at £26 per ton, although the cost of production was £33 per ton. Of course they could not carry on and the plant had been idle since 1920. They could have carried on if they could have obtained £40 per ton, but against that figure they had to compete with the price of £17 per ton charged by Austrian and German manufacturers. If the duty under the act was imposed it would enable his firm to resume operations. The inquiry was adjourned until Jan. 14, when the proceedings will be in private.

The Coal-Tar Products Market 1920, 1921 and 1922

The present condition of the coal-tar products market is due directly to the forces that have been at work during 1920 and 1921. In 1920 America reached its banner year of foreign business. Resale merchants contracted for large supplies of intermediates, with prospects of making turn-overs at large profits to foreign customers. American products were greatly in demand and even though the exchange was very unfavorable, there were no other countries in a position to compete successfully with the United States. In the midst of this flurry of speculation and immense profits came the sudden reversal of affairs following the announcement of the collapse of the Japanese financial system. America with its inflated values became the center of deflation. Prices on all commodities took a sharp decline and speculators who had heavy stocks of chemical products added to the economic upheaval. Weak holders began to make their appearance and presently tremendous stocks were thrown into the market to realize ready cash.

By the end of 1920 the American export business in dyes was practically at a standstill. Large shipments of American-made products were brought back and dumped on the open market at ridiculously low prices. Consumers were losing their interest and would purchase only for immediate necessities. In the meantime, Germany became a more im-

portant factor in the domestic market. The extremely favorable position of the mark and the low production costs gave Germany an advantage over the rest of the world. At the beginning of 1921 the resale merchants were overstocked with dyes and intermediates and many of the plants of the domestic producers were closed tight waiting for favorable developments.

The coal-tar products market remained practically unchanged during 1921. An occasional advance on some particular commodity might be reported, but in general there were no outstanding features in the market. Prices have been reduced by producers consistent with manufacturing

COMPARATIVE PRICES OF COAL-TAR PRODUCTS, JANUARY, 1921-JANUARY, 1922

Article	Jan., 1921	April, 1921	June, 1921	Oct., 1921	Jan., 1922
benzene, c.p., gal.	\$0.32	\$0.27	\$0.27	\$0.27	\$0.29
Cresylic acid, 95-97%, gal.	.90	.85	.65	.65	.65
Dip oil, 25%, gal.	.38	.40	.40	.30	.31
Solvent naphtha, water white, gal.	.30	.25	.25	.25	.25
Toluene, water white, gal.	.33	.28	.28	.28	.30
Xylene, pure, gal.	.42	.42	.40	.40	.40
H acid, lb.	1.40	1.30	1.20	1.10	1.00
Phthalic anhydride, lb.	.60	.50	.50	.40	.37
Salicylic acid, tech., lb.	.30	.22	.19	.18	.20
Alpha naphthylamine, lb.	.40	.38	.35	.30	.30
Aniline oil, lb.	.22	.19	.20	.17	.17
Aniline salt, lb.	.27	.26	.26	.24	.25
Anthracene, 80%, lb.	.90	.75	.75	.75	.75
Benzaldehyde, U.S.P., lb.	1.10	1.00	1.50	1.25	1.35
Benzoate of soda, U.S.P., lb.	.75	.65	.55	.52	.52
Benzidine, base, lb.	1.00	.90	.85	.90	.90
Benzidine, sulphate, lb.	.85	.75	.75	.75	.75
Beta naphthol, tech., lb.	.40	.33	.37	.31	.30
Dichlorobenzene, lb.	.08	.06	.06	.06	.06
Dinitrobenzene, lb.	.35	.32	.26	.23	.21
Diethylaniline, lb.	1.35	1.20	1.20	1.00	.90
Dimethylaniline, lb.	.70	.50	.40	.41	.40
Dinitrophenol, lb.	.40	.35	.35	.35	.38
Diphenylamine, lb.	.70	.60	.60	.60	.60
Naphthalene, flake, lb.	.08	.08	.07	.06	.07
Naphthalene, ball, lb.	.08	.09	.08	.08	.08
Nitrobenzene, lb.	.14	.12	.12	.12	.11
Ortho-nitro-toluene, lb.	.25	.17	.15	.15	.15
Para-phenylenediamine, lb.	2.25	1.95	1.75	1.70	1.65
Para-aminophenol, base, lb.	2.10	1.75	1.50	1.40	1.30
Para-aminophenol, HCl, lb.	2.20	1.95	1.75	1.65	1.55
Para-dichlorobenzene, lb.	.12	.15	.15	.14	.15
Paranitraniline, lb.	.93	.90	.85	.77	.77
Phenol, U.S.P., lb.	.12	.11	.11	.09	.11
Resorcinol, tech., lb.	2.75	1.75	1.75	1.50	1.50
Toluidine, mixed, lb.	.45	.40	.40	.43	.35

costs. However, it is believed that there will have to be a great many more revisions before the industry can compete in any successful manner with the German interests. The domestic producer maintains that freight rates must come down and that a protective tariff must be enacted.

The past few weeks have provided a few encouraging features. Phenol has been advanced and so also have the quotations on benzene and naphthalene. Japan has again become a consistent buyer of heavy tonnages of phenol and exports of benzene to England have resulted in a noticeable shortage in the domestic market. The consuming industries have again shown an urgent demand for naphthalene and have purchased large quantities on contract for the rest of the year. With these outstanding features and the general feeling of confidence that is permeating the entire industry, it is believed that we can look forward hopefully toward a marked revival in the coal-tar products industry.

The Outlook in the Fertilizer Industry

The fertilizer business, emerging from the worst year in its history, has definitely turned the corner and is looking forward to better business conditions in 1922. This is the view expressed by a number of industrial leaders in an article appearing recently in the *Wall Street Journal*. Among the encouraging factors are the better inventory conditions, the reduction of bank loans, and finally the lower freight rates on fertilizer, effective Jan. 1.

The three leading factors in the trade, controlling as much as 55 per cent of the industry, suffered losses in operation for the first time in 60 years. Although this was primarily caused by the agricultural situation, one of the contributing causes was the large amounts charged to inventories for reduction in prices to market levels. For instance, the American Agricultural Chemical Co. absorbed in income account \$5,022,731 for deductions on account of writing inventories down to market levels.

Russia Introduces the Metric System

According to a decree of the Peoples Commissars published in official Soviet papers, the metric system of measures has been introduced in all Soviet institutions beginning with January, 1922, and from 1924 the metric system of weights and measures must be finally and universally adopted throughout Soviet Russia.

New Schedule for Classification of Exports of Domestic Commodities

A new schedule governing the classification of exports of domestic commodities was put into effect Jan. 1 by the Bureau of Foreign and Domestic Commerce. In order that the new regulations in regard to statistical returns of exports may be carried into effect, J. Hohn, the chief of the bureau's division of statistics, points out that the co-operation of exporters is essential. It is absolutely necessary to the accuracy of the statistics that the shipper fill out his export declaration in accordance with the new classification.

Texas Leads in Oil Production

Texas is leading the country in petroleum production, and the different fields in the state are showing a strong tendency to increase present outputs. The Mexia field, one of the latest to be developed, has advanced from an average of 35,000 bbl. a day in November to more than 95,000 bbl. per day at the close of the year. Within 12 hours' travel from Dallas more than one-half the oil of the United States is now being produced. This includes the Mexia field, the Burkburnett district, averaging about 40,000 bbl. a day, and the Stephens County oil regions, with an output approximating 55,000 bbl. daily.

The London Market

FROM OUR SPECIAL CORRESPONDENT

LONDON, Dec. 17, 1921.

The general tone, both in financial circles and in chemical markets, is improving and decidedly optimistic, with a fairly brisk demand and a slight rise in the general level of prices. Acetone, formaldehyde, lithopone, sodium acetate and certain coal-tar intermediates have been in request, particularly for prompt delivery. It is expected that after the approaching stocktaking period there will be a gradual departure from the present unfortunate habit of buying from hand to mouth, and with the removal of anxiety in various directions as to payments of preference dividends, sound business seems in sight.

The New York Market

NEW YORK, Jan. 9, 1922.

The only trading of any importance in the chemical market during the past week was the contract transactions among leading manufacturers. Consumers have been purchasing for future delivery in better volume than at any period during 1921 and producers are inclined to believe that these signs mark the beginning of better times for the industry. Importations have been falling off because of rising prices abroad and consumers have hesitated to place any large tonnage orders with importers for fear of non-delivery. The exchange rates have been a big factor in keeping prices higher abroad as well as maintaining steady prices for spot stocks.

GENERAL CHEMICALS

Although trading in the spot market remained dormant, prices did not sag, but in general continued to be steady. Imported bleaching powder has had a rather evident effect on the market and the domestic producers have been forced to reduce prices to meet this competition. German bleach is quoted here at \$1.80 per 100 lb. Domestic prices are around \$2.25 per 100 lb. f.o.b. works. *Bichromate of soda* has remained steady for the past month, with spot quotations around 7½c. per lb. and contract prices at 7½c. Imported *magnesium sulphate*, technical, is quoted around \$1.05 per 100 lb., with a possibility of shading on firm business. Makers quote \$1.85 per 100 lb., but apparently are willing to consider lower prices. Importers of *barium chloride* have raised their prices and quotations range around

\$53 per ton ex-dock New York. Manufacturers of *sulphuric acid*, 66 deg., have reduced their figures to a basis of \$16.50 per ton, tank cars, f.o.b. works. A larger volume of business has been reported at the newly reduced prices. Quotations on imported *arsenic* are higher for spot and shipment and prices range around 6c. per lb. for immediate shipment from Japan. Spot prices are higher at 6½c. @ 7c. per lb., according to brand. Prices of *caustic potash*, 88-92 per cent, on spot are being well maintained and holders are asking 6c. per lb., this figure representing the lowest possible price. Resale prices of *soda ash* and *caustic soda* were a trifle higher on spot, but contract quotations remained quothably unchanged. Imported *tartaric acid* was slightly cheaper on spot. U.S.P. crystals were offered at 25½c. per lb. Domestic producers still quote 32c. per lb., f.o.b. New York.

COAL-TAR PRODUCTS

The coal-tar products market showed very little change during the past week. Second-hand merchants find difficulty in moving any stocks and producers are still patiently awaiting some definite action that might stir up the industry. Contract bookings have been very scarce for the new year and dealers are practically at a loss to quote intelligently in the absence of any real business. Refiners of *benzene* have advanced their prices 2c. per gal., owing to the acute scarcity of supplies and the heavy demand. Prices on c.p. benzene are now quoted at 29@35c. per gal. in tank cars and drums. The 90 per cent grade is proportionately higher at 27@32c. per gal. *Naphthalene* refiners have also raised their prices after holding quotations at 6½c. per lb. for the past month. Prices for contracts now range from 7½@8½c. per lb. for the flake, according to quantity, and 8½@9½c. for the ball, on the same basis. The demand has been very good in the past week, since resale dealers have been unable to offer any fair-sized quantities for forward deliveries.

The St. Louis Market

ST. LOUIS, MO., Jan. 7, 1922.

The chemical and drug market has closed one of the most uncertain years in its history. However, the conditions prevailing are far healthier and buying can again be resumed with more confidence. The market has been pretty well cleared of the small broker and second-hand dealer, which has been a constant annoyance during the year just closed, but the heavy importations still continue to be a disturbing element. Many prominent and leading factors prophesy a great expansion in business for this year, and it is hoped that their prophecies will not fall short.

ALKALIS

The price on *caustic* has not changed since our last report, but the market is somewhat firmer. Several contracts were made here in the last few days extending over the year 1922 which would seem to indicate that the consumer believes that prices have reached bottom. While these contracts carry protection against decline, they are firm orders and for large quantities. Carload price for solid 76 per cent in drums is \$3.40 per 100 lb., f.o.b. point of production, less than carlots \$4.25 per 100 lb. in single drums, with slight decline on 10-drum lots. Flake 76 per cent in carlots is \$4 per 100 lb., f.o.b. point of production, in drum lots \$4.75@5 per 100 lb. *Soda ash* is \$2.90 per 100 lb., *bicarbonate of soda* \$2.50 per 100 lb. and *sal soda* \$2 per 100 lb. in less than carlots, with the market very inactive.

SPECIAL AND GENERAL CHEMICALS

A decided improvement has been noted in the demand for *aqua ammonia*, 26 deg., since the reduction. *Bismuth salts* have been in continual demand for several months, and apparently there will not be the usual lull this season. *Bromides* are not moving to a great extent, but manage to keep up with previous months. There is very little demand for *cream of tartar* and the market is uninteresting. *Creosotes* continue to hold an active position. *Glycerine* is still advancing, latest quotations for contract prices being 16c. The market is well sold up, and producers are firmly in control. *Sulphur* continues to move slowly, but manages to hold its previous place at \$2 per 100 lb. Apparently no

contract business is being done at present, only spot goods being used.

ACIDS

There is nothing of great importance to mention in connection with the heavy commercial mineral acids. There is a constant and regular demand and a slight increase is noticeable. There has not been much change in the *citric acid* situation, and if anything the demand is somewhat better. The demand for *acid carbolica*, medicinal grade, is increasing and factors are capable of handling big business. *Acid phosphoric sirupy* is very slow. *Tartaric acid* business is practically nil.

VEGETABLE OILS AND NAVAL STORES

Castor oil continues firm, easily maintaining its new price of 13c. in drums. That price is being shaded slightly on contract business, but all spot goods is being held at above price. *Linseed oil* is advancing, keeping step with the flaxseed market, which is now very firm. Producers of linseed oil expect a tariff on imported goods, and predict an increase of 10c. per gal. with the passage of the tariff measure. Contract business for a further period than May is being refused at 67c. *Turpentine* has shown a slight advance, reaching 86c. in single barrels and 82c. in 5-bbl. lots.

PAINT MATERIALS

The paint industry continues optimistic and substantiates its views by some good-sized orders. *Barytes* remain nominal, with movement slightly increasing. The *lithopone* manufacturers expect to be active soon, although imported goods have somewhat disturbed the market. *Whiting* in carlots can be had at around \$13, f.o.b. cars St. Louis, and at \$15 in ton lots f.o.b. buyer's door.

The Iron and Steel Market

PITTSBURGH, Jan. 6, 1922.

The steel market enters the new year in better condition than would have been predicted from the practically universal reports of dullness in trade circulated in December. Few mills closed over the holidays, and the mills in general seem to have order books that will carry them in January with a production similar to production in the last 3 months of the old year.

The personal equation of the mills, so to speak, appears to have changed. There have been times when the mills colored somewhat too brightly the picture they drew of the trade they were enjoying. Of late, it would appear, they are disposed to minimize their trade. Presumably this is an outcome of the strongly competitive conditions that have existed in the market for 5 or 6 months. Each mill is indisposed to give its competitors an exaggerated idea of the volume of business it has obtained, lest the other mills seek by more strenuous competition to equal the record.

Production of steel ingots was fairly uniform during the last 3 months of 1921 at a rate of about 23,000,000 tons a year. Appearances are that mills will closely approach this rate even in January, and possibly exceed it, while in February and March, on account of seasonal conditions, the rate is likely to be exceeded.

What may be regarded as fundamental commercial conditions had little to do with the fluctuations in operating rates of the steel mills in 1921. The liquidation of stocks was the chief factor, hence it may be assumed that with general business conditions no better than they have been in the past few months the steel industry would be called upon to operate indefinitely at a rate of about 23,000,000 tons, while any improvement at all in general conditions would cause this rate to be exceeded. A change in conditions whereby there would be more incentive to regular investment construction would be a great aid to steel demand. There has been much building in the United States in the past few months, but chiefly in garages and dwelling houses, which do not require much steel.

Such a change cannot be predicted for any time within the next few months. In more immediate prospect is a movement on the part of buyers to restore their stocks

part way to normal, say to 70 per cent of what is considered necessary and desirable for the efficient conduct of business, whether the business be that of manufacturing wares made from steel or distributing steel from the jobbing warehouse. All buyers reduced stocks in 1921 to an absolute minimum, partly on account of business uncertainties, partly on account of doubt as to steel prices, and partly as a general measure to liquidate in preparation for making a fresh start.

Steel prices are now relatively stable and there is encouragement to buyers to restore stocks, at least partially. As a matter of fact some conservative but well-posted distributors began even in December to build up stocks. Such a restocking, if only to one-half of normal, would provide a very substantial tonnage of business for the steel industry temporarily, and might send the rate of ingot production up to 30,000,000 tons a year before April 1.

STEEL PRICES STEADIER

As to steel prices, they are distinctly steadier, on the whole, than at any time for months. They have not advanced, nor are they at all likely to advance, but from the prices currently quoted as representing the market in general there are smaller concessions possible in the case of large and desirable orders than were possible some time ago. Last August, when openly quoted prices were materially higher than at present, the extreme prices were probably fully as low as extreme prices are today.

One cause of the greater stability at present undoubtedly is that mills have a more exact appraisal as to the possibilities of operating. Last summer and early fall there was a disposition to make large concessions to build up an order book and get the lower production costs that would come from a larger operation. Prices were quoted not on the basis of existing cost but on a prospective cost based on a problematical operation. Today the mills know just about what operating rate to expect, and realize that they cannot swell the rate materially by cutting prices. Hence their prospective cost can be estimated with a considerable degree of accuracy, and there is excellent reason for believing that no mill of any size will knowingly sell steel at less than the prospective cost of production. Profits, of course, are not being sought and in not a few cases a slight loss might be tolerated for the purpose of giving employment to the men.

The market in general, unchanged in the past couple of weeks, now stands substantially as follows: Bars, shapes and plates, 1.50c.; hoops, bands and hot-rolled strip, 2c.; plain wire, 2.25c.; wire nails, \$2.50; standard steel pipe, 71 per cent basing discount; black sheets, 3c.; galvanized sheets, 4c.; tin plate, \$4.75. The American Steel & Wire Co., on account of price cutting by independents, has reduced its price on cold-rolled strip, effective Jan. 1, from 3.75c. to 3.50c.

PIG IRON

Pig iron continues very dull, but a buying movement of some proportions in foundry iron is expected toward the latter part of the month. A recent sale of basic iron by a steel works interest at \$18.25 valley is now accepted by merchant furnaces as representing current value, the market having previously been quotable nominal at \$19 valley. Bessemer remains quotable at \$20 valley, and foundry at \$19.50@20 valley.

COKE

Contracts for Connellsville furnace coke for first quarter have been made at from \$3.50 down to \$3.25, and the latter price can now be done by buyers. It is said in some quarters that those who paid \$3.50 and \$3.40 bought too soon.

Of considerable interest is a transaction between the Youngstown Sheet & Tube Co. and the Trumbull-Cliffs Furnace Co., involving a coke supply for the Trumbull-Cliffs furnace, Warren, Ohio, of about 18,000 tons a month. This is a requirement contract, predicated on whether the furnace operates, while the seller reserves the right to discontinue the arrangement if it needs the coke for its own furnaces. The price is equal to \$2.90, Connellsville basis. The price was not competitive, it appears, but was made to justify the furnace being blown in.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

	Carlots	Less Carlots
Acetic anhydride.....lb.		\$0 40 - \$0 45
Acetone.....lb.	\$0 12 - \$0 12 1/2	13 - 13 1/2
Acid, acetic, 28 per cent.....100 lbs.	2 50 - 2 60	2 65 - 3 00
Acetic, 56 per cent.....100 lbs.	5 00 - 5 25	5 30 - 5 50
Acetic, glacial, 99 1/2 per cent, carboys, 100 lbs.	10 00 - 10 50	10 75 - 11 00
Boric, crystals.....lb.	12 - 12 1/2	13 - 13 1/2
Boric, powder.....lb.	12 - 13	13 1/2 - 14
Citric.....lb.		43 - 45
Hydrochloric.....100 lb.	1 50 - 1 60	1 65 - 2 00
Hydrofluoric, 52 per cent.....lb.	13 - 13 1/2	13 1/2 - 14
Lactic, 44 per cent tech.....lb.	09 - 10	10 - 12
Lactic, 22 per cent tech.....lb.	04 - 04 1/2	04 1/2 - 05
Molybdic, e.p.....lb.	3 00 - 3 25	3 30 - 3 75
Muriatic, 20 deg. (see hydrochloric).....lb.	06 1/2 - 06 1/2	06 1/2 - 07
Nitric, 40 deg.....lb.	06 1/2 - 07	07 - 07 1/2
Nitric, 42 deg.....lb.	06 1/2 - 07	07 - 07 1/2
Oxalic, crystals.....lb.	14 - 15	15 - 16
Phosphoric, 50 per cent solution.....lb.	11 - 11 1/2	11 1/2 - 12 1/2
Picric.....lb.	20 - 25	27 - 35
Pyrogallol, resublimed.....lb.		1 65 - 1 75
Sulphuric, 60 deg., tank cars.....ton		11 00 - 12 00
Sulphuric, 60 deg., drums.....ton		13 00 - 15 00
Sulphuric, 66 deg., tank cars.....ton	16 50 - 17 00	
Sulphuric, 66 deg., drums.....ton	21 00 - 22 00	22 50 - 23 00
Sulphuric, 66 deg., carboys.....ton		
Sulphuric, fuming, 20 per cent (oleum) tank cars.....ton	21 00 - 22 00	
Sulphuric, fuming, 20 per cent (oleum) drums.....ton	23 00 - 23 50	24 00 - 24 50
Sulphuric, fuming, 20 per cent (oleum) carboys.....ton	31 00 - 32 00	33 00 - 34 00
Tannic, U. S. P.....lb.		65 - 75
Tannic (tech.).....lb.	45 - 50	51 - 55
Tartaric, imported crystals.....lb.		25 - 26
Tartaric acid, imported, powdered.....lb.		26 - 27
Tartaric acid, domestic.....lb.		26 - 32
Tungstic, per lb. of WO.....lb.		1 00 - 1 10
Alcohol, ethyl.....gal.		4 75 - 5 00
Alcohol, methyl (see methanol).....gal.		
Alcohol, denatured, 188 proof.....gal.		42 - 43
Alcohol, denatured, 190 proof.....gal.		43 - 44
Alum, ammonia, lump.....lb.	03 - 03 1/2	04 - 04 1/2
Alum, potash, lump.....lb.	03 - 04	04 - 04 1/2
Alum, chrome lump.....lb.	08 - 08 1/2	08 1/2 - 09
Aluminum sulphate, commercial.....lb.	01 - 02	02 - 02 1/2
Aluminum sulphate, iron free.....lb.	02 - 02 1/2	03 - 03 1/2
Aqua ammonia, 26 deg. (750 lb.).....lb.	07 - 07 1/2	08 - 08 1/2
Ammonia, anhydrous, cyl. (100-150 lb.).....lb.	30 - 30 1/2	31 - 33
Ammonium carbonate, powder.....lb.	07 - 07 1/2	08 - 09
Ammonium chloride, granular (white sal ammoniac).....lb.	07 - 07 1/2	07 1/2 - 07 1/2
Ammonium chloride, granular (gray sal ammoniac).....lb.	07 - 07 1/2	07 1/2 - 07 1/2
Ammonium nitrate.....lb.	07 - 07 1/2	07 1/2 - 08 1/2
Amylacetate tech.....gal.		2 00 - 2 40
Arsenic oxide, (white arsenic) powdered lb.....lb.	06 1/2 - 06 1/2	07 - 07 1/2
Arsenic, sulphide, powdered (red arsenic) lb.....lb.	12 - 12 1/2	12 1/2 - 13
Barium chloride.....ton	51 00 - 52 00	53 00 - 60 00
Barium dioxide (peroxide).....lb.	21 - 21 1/2	22 - 23
Barium nitrate.....lb.	07 - 07 1/2	07 1/2 - 09
Barium sulphate (precip.) (blanc fixe) lb.....lb.	03 - 04	04 - 04 1/2
Blanc fixe, dry.....lb.	04 - 04 1/2	
Blanc fixe, pulp.....ton	45 00 - 55 00	
Bleaching powder (see calc. hypochlorite).....ton		
Blue vitriol (see copper sulphate).....ton		
Borax (see sodium borate).....ton		
Brimstone (see sulphur, roll).....ton		
Bromine.....lb.	21 - 22	23 - 28
Calcium acetate.....100 lbs.	1 75 - 2 00	
Calcium carbide.....lb.	04 - 04 1/2	05 - 05 1/2
Calcium chloride, fused, lump.....ton	23 00 - 24 00	24 50 - 28 00
Calcium chloride, granulated.....ton	01 - 02	02 - 02 1/2
Calcium hypochlorite (bleach g powder) 100 lb.....lb.	2 50 - 2 60	2 65 - 3 25
Calcium peroxide.....lb.		1 40 - 1 50
Calcium phosphate, tribasic.....lb.		15 - 16
Camphor.....lb.		90 - 95
Carbon bisulphide.....lb.	06 1/2 - 06 1/2	07 - 07 1/2
Carbon tetrachloride, drums.....lb.	10 - 10 1/2	11 - 12
Carbonyl chloride, (phosgene).....lb.		60 - 75
Caustic potash (see sodium hydroxide).....lb.		
Caustic soda (see sodium hydroxide).....lb.		
Chalk, precip.—domestic, light.....lb.	03 - 04	
Chalk, precip.—domestic, heavy.....lb.	03 - 03 1/2	
Chalk, precip.—imported, light.....lb.	04 - 04 1/2	
Chlorine, gas, liquid-cylinders (100 lb.) lb.....lb.	06 - 06 1/2	06 1/2 - 07
Chloroform.....lb.		38 - 40
Cobalt oxide.....lb.		2 00 - 2 10
Copperas (see iron sulphate).....lb.		
Copper carbonate, green precipitate.....lb.	20 - 20 1/2	21 - 21 1/2
Copper cyanide.....lb.		58 - 60
Copper sulphate, crystals.....100 lb.	5 60 - 5 65	5 70 - 6 25
Cream of tartar (see potassium bitartrate).....ton		
Epsom salt (see magnesium sulphate).....ton		
Ethyl acetate com. 85%.....gal.		60 - 70
Ethyl acetate, pure (acetic ether, 98% to 100%).....gal.		95 - 11
Formaldehyde, 40 per cent.....gal.	10 - 10 1/2	11 - 12
Fullers earth, f.o.b. mines.....net ton	16 00 - 17 00	
Fullers earth—imported powdered—net ton	30 00 - 32 00	
Fusel oil, ref.....gal.		2 50 - 3 00
Fusel oil, crude.....gal.		1 50 - 1 75
Glauber's salt (see sodium sulphate).....lb.		16 - 16 1/2
Glycerine, e.p. drums extra.....lb.		3 80 - 3 90
Iodine, resublimed.....lb.		12 - 18
Iron oxide, red.....lb.		17 00 - 20 00
Iron sulphate (copperas).....ton	15 00 - 16 00	17 00 - 12 1/2
Lead acetate.....lb.	15 - 15 1/2	15 1/2 - 16 1/2
Lead arsenate, powd.....lb.		15 - 20
Lead nitrate.....lb.	08 - 08 1/2	08 1/2 - 09
Litharge.....lb.	06 1/2 - 07	07 - 08
Magnesium carbonate, technical.....lb.	2 65 - 2 70	2 75 - 3 00
Magnesium sulphate, U. S. P.....100 lb.		1 05 - 1 80
Magnesium sulphate, technical.....100 lb.		62 - 63
Methanol, 97%.....gal.		

	Carlots	Less Carlots
Methanol, 97%.....gal.	\$ - \$	\$0 64 - \$0 65
Nickel salt, double.....lb.		11 - 11 1/2
Nickel salt, single.....lb.		12 - 12 1/2
Phosgene (see carbonyl chloride).....lb.		
Phosphorus, red.....lb.	45 - 46	47 - 50
Phosphorus, yellow.....lb.		30 - 35
Potassium bichromate.....lb.	10 - 11	11 - 11 1/2
Potassium bitartrate (cream of tartar).....lb.		24 - 26
Potassium bromide, granular.....lb.		14 - 15
Potassium carbonate, U. S. P.....lb.	11 - 12	12 1/2 - 15
Potassium carbonate, 80-85%.....lb.	04 - 04 1/2	05 - 06
Potassium chlorate, crystals.....lb.	05 - 06	06 1/2 - 12
Potassium cyanide.....lb.		43 - 45
Potassium hydroxide (caustic potash).....lb.	06 - 06 1/2	06 1/2 - 06 1/2
Potassium iodide.....lb.		2 90 - 3 00
Potassium nitrate.....lb.	07 - 07 1/2	08 - 09
Potassium permanganate.....lb.	15 - 16	16 1/2 - 22
Potassium prussiate, red.....lb.	30 - 30 1/2	31 - 31 1/2
Potassium prussiate, yellow.....lb.	24 - 24 1/2	25 - 26
Rochelle salts (see sodium potassium tartrate).....ton		
Sal ammoniac (see ammonium chloride).....ton		
Salt soda (see sodium carbonate).....ton		
Salt cake (bulk).....ton		18 00 - 21 00
Soda ash, light.....100 lb.	1 85 - 2 10	2 15 - 2 50
Soda ash, dense.....100 lb.	2 15 - 2 20	2 25 - 2 50
Sodium acetate.....lb.	04 - 04 1/2	04 1/2 - 05
Sodium bicarbonate.....100 lb.	2 30 - 2 35	2 40 - 2 75
Sodium bichromate.....lb.	07 - 08	08 1/2 - 08 1/2
Sodium bisulphate (nitre cake).....ton	5 00 - 5 25	5 50 - 6 50
Sodium bisulphate powdered, U.S.P.....lb.	04 - 05	05 1/2 - 06
Sodium borate (borax).....lb.	05 - 06	06 - 07
Sodium carbonate (soda).....100 lb.	1 80 - 1 90	1 95 - 2 15
Sodium chloride.....lb.	06 - 07	07 1/2 - 08
Sodium chloride.....long ton	12 00 - 13 00	
Sodium cyanide.....lb.	26 - 26 1/2	26 1/2 - 27
Sodium fluoride.....lb.	10 - 11	11 - 12
Sodium hydroxide (caustic soda).....100 lb.	3 80 - 3 85	3 90 - 4 30
Sodium hypsulphite.....lb.		03 1/2 - 03 1/2
Sodium nitrite.....lb.	06 - 06 1/2	07 - 07 1/2
Sodium peroxide, powdered.....lb.	25 - 26	27 - 30
Sodium phosphate, dibasic.....lb.	04 - 04 1/2	04 1/2 - 05 1/2
Sodium potassium tartrate (Rochelle salts) lb.....lb.		19 - 21
Sodium prussiate, yellow.....lb.	17 - 17 1/2	17 1/2 - 18
Sodium silicate, solution (40 deg.).....100 lb.	1 00 - 1 05	1 10 - 1 30
Sodium silicate, solution (60 deg.).....100 lb.	2 75 - 3 00	3 25 - 3 50
Sodium sulphate, crystals (Glauber's salt) 100 lb.....lb.	1 30 - 1 50	1 60 - 2 00
Sodium sulphide, (sed. 60-62 per cent (conc.) lb.....lb.	04 - 04 1/2	04 1/2 - 05
Sodium sulphite, crystals.....lb.	03 - 03 1/2	04 - 04 1/2
Strontium nitrate, powdered.....lb.	10 - 11	11 - 15
Sulphur chloride, red.....lb.	05 - 05 1/2	05 1/2 - 06
Sulphur, crude.....ton	18 00 - 20 00	
Sulphur dioxide, liquid, cylinders extra.....lb.	08 - 08 1/2	09 - 10
Sulphur (sublimed), flour.....100 lb.		2 25 - 3 10
Sulphur, roll (brimstone).....100 lb.		2 00 - 2 75
Talc—imported.....ton	30 00 - 40 00	
Talc—domestic powdered.....ton	18 00 - 25 00	
Tin bichloride.....lb.	09 - 09 1/2	09 1/2 - 10
Tin oxide.....lb.		39 - 40
Zinc carbonate.....lb.	14 - 14 1/2	15 - 16
Zinc chloride, gran.....lb.	09 - 09 1/2	09 1/2 - 10
Zinc cyanide.....lb.	42 - 44	45 - 47
Zinc dust.....lb.	11 - 11 1/2	11 1/2 - 12 1/2
Zinc oxide, XX.....lb.	07 - 07 1/2	08 - 09
Zinc sulphate.....100 lb.	3 00 - 3 25	3 30 - 3 50

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha-naphthol, crude.....lb.	\$1.00 - \$1.05
Alpha-naphthol, refined.....lb.	1 15 - 1 20
Alpha-naphthylamine.....lb.	30 - 32
Aniline oil, drums extra.....lb.	17 - 18
Aniline salts.....lb.	25 - 26
Anthracene, 80% in drums (100 lb.).....lb.	75 - 1 00
Benzaldehyde U.S.P.....lb.	1 35 - 1 45
Benzidine, base.....lb.	90 - 1 00
Benzidine sulphate.....lb.	75 - 85
Benzoic acid, U.S.P.....lb.	60 - 65
Benzoate of soda, U.S.P.....lb.	52 - 55
Benzene, pure, water-white, in drums (100 gal.).....gal.	29 - 35
Benzene, 90%, in drums (100 gal.).....gal.	27 - 32
Benzyl chloride, 95-97%, refined.....lb.	25 - 27
Benzyl chloride, tech.....lb.	20 - 23
Beta-naphthol benzoate.....lb.	3 75 - 4 00
Beta-naphthol, sublimed.....lb.	70 - 75
Beta-naphthol, tech.....lb.	30 - 34
Beta-naphthylamine, sublimed.....lb.	1 50 - 1 60
Cresol, U. S. P., in drums (100 lb.).....lb.	16 - 17
Ortho-cresol, in drums (100 lb.).....lb.	24 - 26
Cresylic acid, 97-99%, straw color, in drums.....gal.	70 - 80
Cresylic acid, 25-97%, dark, in drums.....gal.	65 - 70
Cresylic acid, 50%, first quality, drums.....gal.	45 - 50
Dichlorobenzene.....lb.	06 - 09
Diethylaniline.....lb.	90 - 1 05
Dimethylaniline.....lb.	40 - 45
Dinitrobenzene.....lb.	21 - 25
Dinitrochlorobenzene.....lb.	25 - 27
Dinitronaphthalene.....lb.	32 - 35
Dinitrophenol.....lb.	38 - 40
Dinitrotoluene.....lb.	25 - 30
Dip oil, 25%, car lots, in drums.....gal.	31 - 35
Diphenylamine.....lb.	60 - 70
H-acid.....lb.	1 00 - 1 10
Meta-phenylenediamine.....lb.	1 10 - 1 15
Monochlorobenzene.....lb.	10 - 12
Monothylaniline.....lb.	1 40 - 1 45
Naphthalene crushed, in bbls.....lb.	07 - 08
Naphthalene, flake.....lb.	07 - 08
Naphthalene, balls.....lb.	08 - 09
Naphthionine acid, crude.....lb.	65 - 70
Nitrobenzene.....lb.	11 - 14
Nitro-naphthalene.....lb.	30 - 35
Nitro-toluene.....lb.	15 - 17 1/2
Ortho-amidophenol.....lb.	9 00 - 9 10
Ortho-dichlorobenzene.....lb.	15 - 20
Ortho-nitro-phenol.....lb.	25 - 30
Ortho-nitro-toluene.....lb.	15 - 20

Ortho-toluidine.....	lb.	20	—	25
Para-aminodiphenol, base.....	lb.	1.30	—	1.35
Para-aminodiphenol, HCl.....	lb.	1.60	—	1.70
Para-dichlorobenzene.....	lb.	15	—	17
Paranitroaniline.....	lb.	77	—	80
Para-nitrotoluene.....	lb.	75	—	80
Para-phenylenediamine.....	lb.	1.65	—	1.70
Para-toluidine.....	lb.	1.15	—	1.25
Phthalic anhydride.....	lb.	37	—	40
Phenol, U. S. P., drums.....	lb.	111	—	15
Pyridine.....	gal.	1.75	—	2.75
Resorcinol, technical.....	lb.	1.50	—	1.60
Resorcinol, pure.....	lb.	2.00	—	2.25
Salicylic acid, tech., in bbls.....	lb.	20	—	21
Salicylic acid, U. S. P.....	lb.	22	—	23
Salol.....	lb.	75	—	77
Solvent naphtha, water-white, in drums, 100 gal.....	gal.	25	—	28
Solvent naphtha, crude, heavy, in drums, 100 gal.....	gal.	14	—	16
Sulphanilic acid, crude.....	lb.	26	—	28
Tolidine.....	lb.	1.20	—	1.30
Toluidine, mixed.....	lb.	32	—	38
Toluene, in tank cars.....	gal.	25	—	28
Toluene, in drums.....	gal.	30	—	35
Xylidines, drums, 100 gal.....	lb.	40	—	45
Xylene, pure, in drums.....	gal.	40	—	45
Xylene, pure, in tank cars.....	gal.	45	—	50
Xylene, commercial, in drums, 100 gal.....	gal.	33	—	35
Xylene, commercial, in tank cars.....	gal.	30	—	35

Waxes

Prices are quotably unchanged for the entire list.

Naval Stores

All prices are f.o.b. New York unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Rosin B-D, bbl.....	280 lb.	\$5.30	—	5.35
Rosin E-F.....	280 lb.	5.40	—	5.50
Rosin K-N.....	280 lb.	6.05	—	6.75
Rosin W. G.-W. W.....	280 lb.	7.00	—	7.25
Wood rosin, bbl.....	280 lb.	6.25	—	—
Spirits of turpentine.....	gal.	.82	—	—
Wood turpentine, steam dist.....	gal.	.80	—	—
Wood turpentine, dest. dist.....	gal.	.79	—	—
Pine tar pitch, bbl.....	200 lb.	—	—	6.00
Tar, kila burned, bbl. (500 lb.).....	bbl.	—	—	9.50
Retort tar, bbl.....	500 lb.	—	—	9.50
Rosin oil, first run.....	gal.	.36	—	—
Rosin oil, second run.....	gal.	.39	—	—
Rosin oil, third run.....	gal.	.46	—	—
Pine oil, steam dist., sp.gr. 0.930-0.940.....	gal.	—	—	\$1.90
Pine oil, pure, dest. dist.....	gal.	1.50	—	—
Pine tar oil, ref., sp.gr. 1.025-1.035.....	gal.	—	—	.46
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.....	gal.	—	—	.35
Pine tar oil, double ref., sp.gr. 0.965-0.990.....	gal.	—	—	.75
Pine tar, ref., thin, sp.gr. 1.080-1.060.....	gal.	—	—	.35
Turpentine, crude, sp. gr. 0.900-0.970.....	gal.	1.25	—	—
Hardwood oil, f.o.b. Mich., sp.gr. 0.960-0.990.....	gal.	—	—	.35
Pinewood creosote, ref.....	gal.	—	—	.52

Fertilizers

Ammonium sulphate, bulk and double bags.....	100 lb.	\$2.30	—	2.90
Blood, dried, f.o.b., N. Y.....	unit	4.00	—	—
Bone, 3 and 50, ground, raw.....	ton	30.00	—	32.00
Fish scrap, dom., dried, f.o.b. works.....	unit	2.90	—	3.00
Nitrate soda.....	100 lb.	2.30	—	2.35
Tankage, high grade, f.o.b. Chicago.....	unit	2.75	—	3.00
Phosphate rock, f.o.b. mines, Florida pebble, 68-72%.....	ton	4.50	—	6.50
Tennessee, 78-80%.....	ton	8.50	—	9.00
Potassium muriate, 80%.....	ton	35.00	—	34.00
Potassium sulphate.....	unit	.95	—	1.00

Crude Rubber

Quotations have remained unchanged since our previous report.

Oils

VEGETABLE

The following prices are f.o.b. New York for carload lots.

Castor oil, No. 3, in bbls.....	lb.	\$0.10	—	\$0.10
Castor oil, AA, in bbls.....	lb.	.11	—	.12
China wood oil, in bbls. (f.o.b. Pac. coast).....	lb.	.13	—	.13
Cocoonut oil, Ceylon grade, in bbls.....	lb.	.08	—	.09
Cocoonut oil, Cochon grade, in bbls.....	lb.	.10	—	.10
Corn oil, crude, in bbls.....	lb.	.09	—	.09
Cottonseed oil, crude (f. o. b. mill).....	lb.	.07	—	.07
Cottonseed oil, summer yellow.....	lb.	.08	—	.09
Cottonseed oil, winter yellow.....	lb.	.09	—	.09
Linseed oil, raw, car lots (domestic).....	gal.	.69	—	.70
Linseed oil, raw, tank cars (domestic).....	gal.	.64	—	.65
Linseed oil, in 5-bbl lots (domestic).....	gal.	.72	—	.73
Olive oil, denatured.....	gal.	\$1.15	—	\$1.20
Palm, Lagos.....	lb.	.07	—	.07
Palm, Niger.....	lb.	.06	—	.06
Peanut oil, crude, tank cars (f.o.b. mill).....	lb.	.08	—	.08
Peanut oil, refined, in bbls.....	lb.	.11	—	.11
Rapeseed oil, refined in bbls.....	gal.	.82	—	.83
Rapeseed oil, blown, in bbls.....	gal.	.88	—	.90
Soya bean oil (Manchurian), in bbls. N. Y.....	lb.	.08	—	—
Soya bean oil, tank cars, f.o.b., Pacific coast.....	lb.	.07	—	—

FISH

Light pressed menhaden.....	gal.	\$0.46	—	—
Yellow bleached menhaden.....	gal.	.48	—	—
White bleached menhaden.....	gal.	.50	—	—
Blown menhaden.....	gal.	.57	—	—

Miscellaneous Materials

Prices remain unchanged throughout the list.

Refractories

All prices remain the same as figures appearing in our Dec. 28 issue.

Ferro-Alloys

All f.o.b. Works

Ferrocobalt-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.....	net ton	\$200.00	—	\$225.00
Ferrocobalt, per lb. of Cr contained, 6-8% carbon, carlots.....	lb.	.12	—	—
Ferrocobalt, per lb. of Cr contained, 4-6% carbon, carlots.....	lb.	.13	—	—
Ferromanganese, 76-80% Mn, domestic.....	gross ton	58.00	—	60.00
Ferromanganese, 76-80% Mn, Foreign, c. i. f. Atlantic seaport.....	gross ton	54.00	—	58.35
Spiegelisen, 18-22% Mn.....	gross ton	25.00	—	27.00
Ferromolybdenum, 50-60% Mo, per lb. of Mo.....	lb.	2.25	—	—
Ferrosilicon, 10-15%.....	gross ton	38.00	—	40.00
Ferrosilicon, 50%.....	gross ton	57.00	—	59.00
Ferrosilicon, 75%.....	gross ton	120.00	—	125.00
Ferrotungsten, 70-80% per lb. of contained W.....	lb.	.40	—	.45
Ferro-uranium, 35-50% of U, per lb. of U content.....	lb.	6.00	—	—
Ferrovanadium, 35-40% per lb. of contained V.....	lb.	4.25	—	4.50

Ores and Semi-finished Products

All f.o.b. New York, Unless Otherwise Stated

Bauxite, 52% Al content.....	net ton	\$8.00	—	\$10.00
Chrome ore, Calif. concentrates, 50% min. Cr ₂ O ₃	ton	22.00	—	23.00
Chrome ore, 50% Cr ₂ O ₃ , f.o.b. Atlantic seaboard.....	ton	22.00	—	23.00
Coke, foundry, f.o.b. ovens.....	net ton	4.25	—	4.50
Coke, furnace, f.o.b. ovens.....	net ton	3.25	—	3.50
Fluorspar, gravel, f.o.b. mines, New Mexico.....	net ton	12.00	—	—
Fluorspar, standard, domestic washed gravel Kentucky and Illinois mines.....	net ton	20.00	—	22.00
Ilmenite, 52% TiO ₂ , per lb. ore.....	unit	.01	—	.01
Manganese ore, 50% Mn, c.i.f. Atlantic seaport.....	unit	.23	—	.24
Manganese ore, chemical (MnO ₂).....	net ton	55.00	—	60.00
Molybdenite, 85% MoS ₂ , per lb. of MoS ₂ , N. Y.....	lb.	.45	—	.50
Monasite, per unit of ThO ₂ , c.i.f. Atlantic seaport.....	unit	30.00	—	—
Pyrites, Spanish, fines, c.i.f., Atlantic seaport.....	unit	.12	—	.12
Pyrites, Spanish, furnace size, c.i.f. Atlantic seaport.....	unit	.13	—	.13
Pyrites, domestic, fines, f.o.b. mines, Ga.....	unit	.11	—	.12
Rutile, 95% TiO ₂ per lb. ore.....	lb.	.15	—	—
Tungsten, scheelite, 60% WO ₃ and over, per unit of WO ₃ (nominal).....	unit	2.50	—	2.75
Tungsten, wolframite, 60% WO ₃ and over, per unit of WO ₃ , N. Y. C.....	unit	2.75	—	3.00
Uranium ore (carnotite) per lb. of U ₃ O ₈	lb.	1.25	—	1.75
Uranium oxide, 96% per lb. contained U ₃ O ₈	lb.	2.25	—	2.50
Vanadium pentoxide, 99%.....	lb.	12.00	—	14.00
Vanadium ore, per lb. of V ₂ O ₅ contained.....	lb.	1.00	—	—
Zircon, washed, iron free, f.o.b. Pablo, Florida.....	lb.	.04	—	.13

Non-Ferrous Metals

New York Markets

Cents per Lb.

Copper, electrolytic.....	13.75
Aluminum, 98 to 99 per cent.....	19.00
Antimony, wholesale lots, Chinese and Japanese.....	4.50
Nickel, ordinary (ingot).....	41.00
Nickel, electrolytic.....	44.00
Nickel, electrolytic, resale.....	38.00
Monel metal, shot and blocks.....	35.00
Monel metal, ingots.....	38.00
Monel metal, sheet bars.....	40.00
Tin, 5-ton lots, Straits.....	32.375
Lead, New York, spot.....	4.70
Lead, E. St. Louis, spot.....	4.40
Zinc, spot, New York.....	5.25@5.30
Zinc, spot, E. St. Louis.....	4.80@4.85

OTHER METALS

Silver (commercial).....	oz.	\$0.64
Cadmium.....	lb.	1.00-1.25
Bismuth (500 lb. lots).....	lb.	1.50@1.55
Cobalt.....	lb.	3.00@3.25
Magnesium (f.o.b. Philadelphia).....	lb.	1.25
Platinum.....	oz.	80.00-84.00
Iridium.....	oz.	150.00@170.00
Palladium.....	oz.	55.00-60.00
Mercury.....	75 lb.	50.00-51.00

FINISHED METAL PRODUCTS AND OLD METALS

Quotations have remained unchanged since our previous report.

Structural Material

The following base prices per 100 lb. are for structural shapes 3 in. by 1/2 in. and larger, and plates 1/2 in. and heavier, from jobbers' warehouses in the cities named:

	New York	Cleveland	Chicago
Structural shapes.....	\$2.78	\$2.88	\$2.78
Soft steel bars.....	2.68	2.78	2.68
Soft steel bar shapes.....	2.68	2.78	2.68
Soft steel bands.....	3.28	3.48	3.28
Plates, 1/2 to 1 in. thick.....	2.78	2.88	2.78

*Add 15¢ per 100 lb. for trucking to Jersey City and 10¢ for delivery in New York and Brooklyn

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

Alabama

BIRMINGHAM—The Great Southern Steel Co., Chicago, Ill., recently organized with a capital of \$105,000,000 under Delaware laws, has plans in preparation for the erection of a new steel plant at Birmingham, estimated to cost about \$500,000 for initial units. The company, also, has about 10,000 acres of iron ore and coal properties in Etowah County and neighboring counties of Alabama, and purposes extensive development and operation of the lands. John W. Baker, 711 Lumber Exchange Bldg., Chicago, is one of the principals in the organization.

ALBANY—A. G. Patterson, Albany, and associates have plans under way for the development of a large tract of asphalt deposits, recently acquired. A plant will be installed.

California

NATIONAL CITY—The California Gypsum Co. has made application to the State Harbor Commission for a lease of tideland property at National City, totaling about 40 acres, to be used as a site for a new plant for the manufacture of gypsum products, estimated to cost approximately \$250,000.

Colorado

FORT COLLINS—Fire, Dec. 22, destroyed the chemical building at the State Agricultural College here, with loss estimated at about \$60,000.

Connecticut

NEW HAVEN—The Seamless Rubber Co., manufacturer of small rubber goods, has awarded a contract to the Dwight Building Co., 67 Church St., for the rebuilding of the portion of its plant, recently destroyed by fire, with loss estimated at \$200,000, including equipment. The new structure will be located on Hallock Ave.

BRIDGEPORT—The D. & C. Oil Co., Lindley St., has awarded a contract to George Lyelos, 220 Parrott Ave., for the erection of its new plant on Colonial Ave., estimated to cost about \$25,000.

Florida

DAYTONA—W. K. Tavel and H. B. Schulte, Daytona, are organizing a new company for the establishment of a local plant for the manufacture of cement brick, shingles and kindred specialties.

MIAMI—The Pennsylvania Sugar Co., 135 South Second St., Philadelphia, Pa., has awarded a building contract for the erection of the first unit of its proposed new sugar mill on property recently acquired near Miami. The plant will have an initial output of about 1,500 tons of cane sugar per day, and is estimated to cost close to \$500,000.

LEESBURG—The Leesburg Pulp Mill Co. is considering preliminary plans for the doubling of its present plant capacity.

TAMPA—The Florida Nu-Tex Brick Co., 109 Water St., is planning for the establishment of a number of branch plants in different sections of the state for the manufacture of cement brick. W. B. Coarsey is president.

MOORE HAVEN—The Moore Haven Sugar Corp. is installing additional machinery at its mill and will begin operations under increased production within a few weeks. This is the first mill of this kind to be established in the Everglades section of the state.

PENSACOLA—The Southern Paving Co. is considering plans for extensions and improvements in its wood-block creosoting plant, to include the installation of tanks and other equipment, estimated to cost about \$40,000.

Indiana

MARION—The Mileage Oil & Refining Co., Kokomo, Ind., has acquired the property of the Service Oil Co., Marion, at a

receiver's sale, for a total consideration said to be \$400,000. The new owner will operate the plant as an extension to present activities.

Kentucky

LOUISVILLE—The Standard Sanitary Mfg. Co., Bessemer Bldg., Pittsburgh, Pa., has awarded a contract to the George Rommel Co., 956 Logan St., Louisville, for the erection of a 1-story addition to its local plant at Sixth and A Sts., to be equipped as an enameling works. It is estimated to cost about \$100,000. O. P. Ward, Lincoln Trust Bldg., Louisville, is architect.

Louisiana

ALEXANDRIA—The Alexandria Refining Co. has taken out a state charter with capital of \$50,000, to construct and operate a local oil refinery. Erection of the new plant has been commenced. H. T. Clark is president, and G. W. Zodar, vice-president.

Maryland

HAGERSTOWN—The Bostwick-Lyon Bronze Co., Waynesport, Pa., operating a plant at Hagerstown under the name of the Hagerstown Bearing Metal Works, has acquired the local plant of the Maryland Smelting & Refining Co., and will merge the property with the Hagerstown works. Extensive operations are planned.

Massachusetts

LOEMINSTER—The Viscoloid Co., Lancaster St., manufacturer of celluloid products, will soon commence the erection of a 2-story plant addition, 40 x 50 ft. The building contract has been let to the Wiley & Foss Co., Fitchburg, Mass.

ARLINGTON—The Frost Insecticide Co. has completed plans and will soon commence the erection of a new plant unit, estimated to cost about \$40,000, including equipment.

Missouri

KANSAS CITY—The Hydro-United Tire Co., Pottstown, Pa., has acquired a controlling interest in the A. J. Stephens Rubber Co., with plant at Kansas City, and plan for increased operations at the works. J. H. Phillips is president of the Hydro-United company.

Montana

GREAT FALLS—The local Commercial Club is developing plans for the organization of a new company, to construct and operate a beet sugar manufacturing plant.

New Jersey

NEWARK—The Gulf Refining Co., Doremus Ave. near the Plank Road, has had plans prepared for the erection of a 1-story, reinforced-concrete machine shop at its local oil plant, 100 x 230 ft., estimated to cost about \$70,000. Headquarters of the company are at 21 State St., New York.

New York

BROOKLYN—The P. L. Andrews Corp., 45 Irving Ave., manufacturer of envelopes and other paper products, has awarded a contract to the Caye Construction Co., 356 Fulton St., for the erection of a new 2-story plant, 55 x 100 ft., on Jefferson St., estimated to cost about \$75,000.

Pennsylvania

SPRING GROVE—The P. H. Glatfelter Co., operating a local paper mill, has completed plans for increasing the capacity of the plant from 50 to 100 tons per day. An extension will be erected to provide for the installation of a new 168-in. machine and other finishing machinery.

ELIZABETHTOWN—The Farmers' Fertilizer Works, William Schneitman, head, is considering the erection of a new 1-story plant for the manufacture of commercial fertilizers.

NEW CUMBERLAND—E. E. Fleurie, Fifth and Reno Sts., is planning for the immediate rebuilding of his brick-manufacturing plant, destroyed by fire, Dec. 23, with loss estimated at about \$25,000. New machinery will be installed.

PITTSBURGH—The H. J. Heinz Co., Progress St., manufacturer of canned food products, has plans in preparation for the erection of a 2-story and basement laboratory building, 40 x 100 ft. Bids will be asked and construction inaugurated at an early date.

Tennessee

GRAYSVILLE—The Dixie Coal, Lime & Clay Products Co., Chattanooga, Tenn., has acquired clay properties in the vicinity of Graysville, totaling about 400 acres, and plans for the installation of a clay-mining plant. It is also proposed to establish a works for the manufacture of firebrick and other burned clay products. The acquisition includes a large tract of lime deposits and a plant will be established for the development.

WHITE PINE—G. M. Felmet, White Pine, and associates, are organizing a new company to construct and operate a local flour mill. Plans are being prepared for a 4-story and basement mill, 36 x 70 ft., and ground will be broken early in the spring. The W. J. Savage Co., 912 West Church St., Knoxville, Tenn., is architect.

Texas

HOUSTON—The Humphreys-Pure Oil Co. interests have organized under Delaware laws the Humphreys-Pure Oil Refineries Corp., with capital of \$50,000,000. The new organization will operate in the Mexia, Tex., oil fields, and plans for the erection of a new oil refinery in the vicinity of Houston, with output of about 30,000 bbl. of oil per day. A pipe line will be constructed from the Mexia district to a point on the Gulf, provided with a series of pumping stations and other operating equipment. The entire project is estimated to cost close to \$5,000,000. Col. E. A. Humphreys heads the company.

NEWCASTLE—The Common Council is perfecting plans for the construction of a new filtration plant at the municipal waterworks. The Henry, Exall, Elrod Co., Dallas, Tex., is engineer.

AMARILLO—The Amarillo Brick & Tile Co. is establishing a plant in the vicinity of clay properties about 6 miles from Amarillo, and will inaugurate operations at an early date.

MCGREGOR—The Koury Calcium Co., recently organized with a capital of \$400,000, has acquired the plant and property of the Lone Star Co. at Oglesby, near Waco, consisting of about 360 acres of lime lands, with plant equipped for an output of about 1,000 bbl. of lime per day. The new owner purposes to operate the plant and develop an extensive output of raw material. The company will also begin operations at an early date on its properties near McGregor, recently acquired, with proposed plant at this location estimated to cost close to \$100,000. Michael Koury is president, and W. V. Hanover, secretary.

HOUSTON—The Texas Co. has started preliminary work at its sulphur deposits at Haskins Mound, Tex., and has blocked out an area to provide for an output of over 10,000,000 tons. It is said that plans are being perfected for the organization of a subsidiary company, to be capitalized at \$5,000,000, for the operation of the lands, and to construct a large plant in this vicinity. Considerable equipment will be purchased for installation.

Virginia

RICHMOND—The Manchester Board & Paper Co., West Canal St., is planning for extensions and improvements in its plant to cost about \$15,000.

CHARLOTTESVILLE—The City Council has plans under way for the installation of a new filtration plant on Observatory Mountain for the waterworks system, estimated to cost about \$130,000. Williamson, Carroll & Saunders, Charlottesville, are engineers.

West Virginia

HUNTINGTON—The International Nickel Co., 67 Wall St., New York, is maintaining active construction on its new local plant, which is now more than 50 per cent completed. The works comprise a refinery and rolling mill, and will be used primarily for the manufacture of Monel metal products. It is intended to have the plant ready for operation early in May. W. L. Wotherspoon, company address, is engineer.

Wisconsin

APPLETON—The Appleton Coated Paper Co. has broken ground for the erection of a new 3-story and basement building at its plant, estimated to cost about \$35,000. Charles Boyd is manager.

Capital Increases, Etc.

THE FLINT VARNISH & COLOR WORKS. Flint, Mich., has filed notice of increase of capital from \$1,500,000 to \$3,500,000.

THE HOOKER ELECTROCHEMICAL CO., 25 Pine St., New York, N. Y., with plant at Niagara Falls, N. Y., has disposed of a bond issue of \$1,250,000, the proceeds to be used for general financing, operations, etc.

THE INLAND METALS REFINING CO., 4837 South May St., Chicago, Ill., has filed notice of dissolution under state laws.

THE NATIONAL CARBIDE CORP., a Virginia corporation, has filed notice of intention to operate in New York, with capital of \$350,000. E. V. O'Daniel, 342 Madison Ave., New York, is representative.

THE VERSAILLES SANITARY FIBRE MILLS, INC., Sprague, Conn., has filed notice of increase in capital from \$300,000 to \$500,000.

THE AMERICAN SUGAR REFINING CO., 117 Wall St., New York, has arranged for a bond issue of \$30,000,000, the proceeds to be used for general financing, operations, etc.

THE GRANDFIELD OIL & REFINING CO., Grandfield, Okla., has filed notice of increase in capital from \$125,000 to \$300,000 for proposed expansion.

THE ECONOMY PAPER CO., 847 Broad St., Newark, N. J., has filed notice of increase in capital from \$6,000 to \$125,000 for general expansion.

THE UNION CHARCOAL & CHEMICAL CO., a Delaware corporation, has filed notice of intention to operate in New York, with capital of \$250,000. C. M. Hancock, Olean, N. Y., is representative.

THE FEDERAL MICA CO., 217 Center St., New York, N. Y., has filed notice of dissolution under state laws.

New Companies

THE SOUTH HAVEN CHEMICAL CO., South Haven, Mich., has been incorporated with a capital of \$25,000, to manufacture chemicals and chemical byproducts. The incorporators are J. C. Randall, J. C. Johnston and John C. Hunt, all of South Haven.

THE C. B. CASTLE CORP., New York, N. Y., has been incorporated with a capital of \$10,000, to manufacture oils, greases, etc. The incorporators are W. W. Heaton, W. B. Seawell and J. K. Berry. The company is represented by Porter & Taylor, 30 Broad St., New York.

THE CHEMICAL CONVERTING CO., 15 Exchange Pl., Jersey City, N. J., has been incorporated with a capital of \$100,000, to manufacture chemicals and affiliated products. The incorporators are Martin J. Connolly, Edward F. Johnston and Paul Henderson.

THE JOHNSON OIL REFINING CO., 208 South La Salle St., Chicago, Ill., has been incorporated with a capital of \$2,000,000, to manufacture petroleum products. The incorporators are G. C. Lilly, I. H. and Homer H. Johnson.

THE GOOCH, OTIS CO., INC., Boston, Mass., has been incorporated with a capital of \$25,000, to manufacture leather products. Albert N. Gooch is president, and Walter I. Otis, Everett, Mass., treasurer.

THE INSULATING PRODUCTS CO., Kalamazoo, Mich., has been incorporated with a capital of \$25,000, to manufacture insulating specialties, pipe coverings and kindred products. The incorporators are Bailey A. Wright, Fred W. Myers and Donald F. Osborne, all of Kalamazoo.

THE RODIAN ELECTRO-METALLURGICAL CO., INC., Wilmington, Del., has been incorporated under state laws with capital of \$10,000,000, to manufacture various metallurgical products. The company is represented by the Corporation Trust Co. of America, du Pont Bldg., Wilmington.

THE ADVANCE CHEMICAL MFG. CO., 2756 Diversey Ave., Chicago, Ill., has been incorporated with a capital of \$50,000, to manufacture chemicals, compounds, etc. The incorporators are Jacob Kaplan and Samuel L. Steinberg.

THE J. K. MCIVER CO., Savannah, Ga., has been organized under state laws to manufacture fertilizer products. The company is headed by J. K. Mciver and Bleeker P. Seaman, both of Savannah.

THE RUBBER PRODUCTS CO., Morgantown, W. Va., has been incorporated with a capital of \$50,000, to manufacture rubber specialties. The incorporators are Earl Pepper, M. J. Melampy, Jr., and C. W. Huston, all of Morgantown.

THE PRO-RALGIA CHEMICAL CO., Pittsburgh, Pa., has been incorporated with a capital of \$5,000, to manufacture chemicals

and chemical byproducts. H. A. Hauser, 323 Bailey Avenue, is treasurer.

THE LYNN IRON FOUNDRY, INC., Lynn, Mass., has been incorporated with a capital of \$20,000, to manufacture iron, steel and other metal castings. Telephor Mailoux is president; and I. George Pelletier, Salem, Mass., treasurer.

THE U. N. S. PAPER BOX CO., New York, N. Y., has been incorporated with a capital of \$25,000, to manufacture paper boxes and kindred products. The incorporators are R. Benrey, S. Redler and D. Crespi. The company is represented by W. R. Altman, 277 Broadway, New York.

THE SILVER REDUCTION CO., 155 North Clark St., Chicago, Ill., has been incorporated with a capital of \$20,000, to manufacture metal products. The incorporators are Emerson B. Stoddard, Charles E. Johnson and Ralph E. Rich.

THE DURAND-WILCOX GLASS CO., Newfield, N. J., has been incorporated with a capital of \$100,000, to manufacture glass products of various kinds. The incorporators are M. D. and Victor Durand, Jr., and Albert C. Wilcox, all of Newfield.

THE AMERICAN EAGLE OIL CO., Taft, Cal., has been incorporated with a capital of \$500,000, to manufacture petroleum products. The incorporators are J. B. Baker, O. R. Tucker, A. S. Johnston and R. E. Havenstrite, all of Taft.

THE MARYLAND FELT & PAPER CO., Calvert Bldg., 101 East Fayette St., Baltimore, Md., has been incorporated with a capital of \$1,000,000, to manufacture paper and other kindred products. The incorporators are Joseph P. Murray, Frank S. Muzzey, and P. Stanley Saurman.

THE CONRAD FOUNDRY CO., 615 Montgomery Ave., Elizabeth, N. J., has been incorporated with a capital of \$100,000, to manufacture steel, iron and other metal castings. The incorporators are John F. Conrad, William R. Miller and John Ebel.

THE TRUSTEES CHEMICAL CORP., Wilmington, Del., has been incorporated under state laws with capital of \$500,000, to manufacture chemicals, compounds etc. The company is represented by the Corporation Service Co., Wilmington.

THE SAN CHEMICAL CO., Columbia, S. C., has been incorporated with a capital of \$50,000, to manufacture chemicals and chemical byproducts. J. S. Hammoch is president and treasurer; J. B. Pratt, vice-president; and E. H. Salmon, secretary, all of Columbia.

THE ESSEX CHEMICAL & SPECIALTY CO., Newark, N. J., has been incorporated with a capital of \$50,000, to manufacture chemicals, compounds, etc. The incorporators are Emanuel P. Scheck, I. V. Davis and Harry E. Young, 790 Broad St., Newark.

THE STORAGE PRODUCTS CORP., New York, N. Y., has been incorporated with a capital of \$100,000, to manufacture cement, asphalt and kindred products. The incorporators are S. D. Joseph, A. M. Steinberg and B. Mayer. The company is represented by E. Enselman, 220 Broadway, New York.

THE SURE LIFE PRODUCTS CO., Wilmington, Del., has been incorporated under state laws with capital of \$250,000, to manufacture polishes, dyes and kindred chemical specialties. The company is represented by the Capital Trust Co. of Delaware, Dover, Del.

THE VALLEY TILE & CONCRETE CO., San Benito, Tex., has been incorporated with a capital of \$10,000, to manufacture cement tile and kindred specialties. G. W. Wilkerson, San Benito, is president.

THE COMANCHE POINT OIL CO., Los Angeles, Cal., has been incorporated with a capital of \$1,000,000, to manufacture petroleum products. The incorporators are J. S. Farrow, B. S. Hunter, J. N. Kerwin and Glenn N. Duell. The company is represented by Benjamin S. Hunter, Citizens' National Bank Bldg., Los Angeles.

THE PENNSYLVANIA SOAP CO., Pittsburgh, Pa., has been incorporated under Delaware laws, with capital of \$250,000, to manufacture soaps and kindred products. The incorporators are Arthur C. Volbrecht, Louis A. Snyder. The company is represented by the Capital Trust Co. of Delaware, Dover, Del.

THE OSANTOS CHEMICAL CO., 110 South Dearborn St., Chicago, Ill., has been incorporated with a capital of 400 shares of stock, no par value, to manufacture chemical compounds, etc. The incorporators are A. M. Dombey, F. W. Metz and Thomas S. Milcarek.

THE KNOXVILLE CEMENT PRODUCTS CO., Oakwood, near Carbondale, Tenn., has been incorporated with a capital of \$10,000, to manufacture cement specialties. The incorporators are Chester Koehn, Harmon Austin and Charles A. Russell, Oakwood.

THE SENSO MFG. CO., Fort Wayne, Ind., has been incorporated with a capital of \$10,000, to manufacture chemical compounds, disinfectants, etc. The incorporators are C. J. Shimer, R. J. Brown and J. C. Beyer.

THE HAGMAYER CHEMICAL & MFG. CO., Philadelphia, Pa., has been incorporated under Delaware laws, with a capital of \$100,000, to manufacture chemicals, paints, etc. The company is represented by the Corporation Guarantee & Trust Co., Land Title Bldg., Philadelphia.

THE TRENTON CHEMICAL CO., Trenton, N. J., has been organized under state laws to manufacture chemicals and chemical byproducts. The company is headed by F. Walter Messier and M. L. Ward Suydam, 1109 Division St., Trenton.

THE SOUTHERN PACIFIC BRICK & TILE CO., Fresno, Cal., has been incorporated with a capital of \$250,000, to manufacture brick, tile and other burned clay products. The incorporators are W. H. Shields, Fresno; W. D. Trehwitt, Hanford, Cal.; and L. E. Hayes, Exeter, Cal.

THE PHOENIX CHEMICAL WORKS, INC., Houston, Tex., has been incorporated with a capital of \$50,000, to manufacture chemicals and chemical byproducts. The incorporators are John Pfeiffer, E. J. Blunt and M. H. Webster, Houston.

THE SHOPE BRICK CO., Springfield, Mass., has been incorporated with a capital of \$125,000, to manufacture brick, tile and other burned clay products. William J. Kressler is president; Paul G. Seyler, vice-president; and Edward F. Seyler, treasurer, all of Springfield.

Manufacturers' Catalogs

W. S. ROCKWELL CO., New York, has just issued Bulletin 234, on "The Continuous Heat-Treatment of Metals With Automatic and Semi-Automatic Furnaces," which is the fourth of the series dealing with fundamentals that influence the quality and cost of heated products. This bulletin illustrates practical applications of the principles outlined by the previous bulletins of this series—namely, Nos. 230, 231 and 232. Attention is also called to Bull. 239, which relates to an improved type of forge furnace. The novel features of the furnace consist of means for better application of the heat, protection of the operator, and utilization of waste gases to preheat air and fuel for combustion.

THE ALBERGER CHEMICAL MACHINERY CO., New York, has issued Bulletins 34 and 36, on the Nelson filter presses and Alberger vertical mixers.

THE ENGINEERING MAGAZINE CO., New York City, in November, started publication of a new magazine known as *Industry Illustrated*.

THE STURTEVANT MILL CO., Boston, Mass., has made a new departure in the production of a catalog showing the use of Sturtevant equipment in the fertilizer industry. It has published a pretentious treatise entitled "The Modern Fertilizer Plant," covering every step in the production of fertilizer from rock phosphates. From the time the phosphate rock is received in box cars, from which it is removed by a power shovel, to the mechanical sacking and shipping of the finished product, every intermediate step is described and illustrated. Unquestionably this is one of the most complete treatments of an industrial process that has been covered in catalog form.

THE WHEELER CONDENSER & ENGINEERING CO., Carteret, N. J., has issued a new catalog on centrifugal pumps, catalog 108-C, which described construction details and fully illustrates the application of high-efficiency double suction pumps for every purpose. Single-stage horizontal and vertical shaft pumps and multi-rotor pumps are included. Of special interest are the illustrations of circulating pumps for condensers of all sizes. Several types are also shown for each of the other usual pumping services, many of special and unusual design. Methods are given for constructing the characteristic curves of a centrifugal pump at varying speeds where the characteristics are known for constant speed operation. Instructions are given for installing and operating centrifugal pumps and also many useful data for making calculations and writing specifications.

THE ELECTRO-REFRATORIES CORP., Elliott Sq., Buffalo, has issued a circular describing its new Terecod crucible which gives a list of the particular advantages such as high-conductivity, non-scalping, non-scaling, clean-pouring, etc.

Industrial Notes

THE RUBBER SERVICE LABORATORIES CO. appears in the list of new Ohio corporations. The incorporators are given as R. C. Hartong, C. W. Bedford, C. O. North and C. N. Hand, all formerly connected with the development department of the Good-year Tire & Rubber Co. This concern will manufacture organic accelerators and other materials for the rubber trade and furnish free consultation service with its products, offering its entire staff for consultation, development and routine service to rubber and related industries. It will function as an auxiliary department to supplement the existing staff of its clients or to furnish such service to small rubber companies which do not maintain development departments. This service will be rendered on a highly ethical basis. It is not the policy of this company to "peddle formulas" or to disclose the secrets of its clients. It will develop formulas for specific uses or improve existing compounds, install new processes or modify old ones and aid in the development of suitable materials for the rubber trade in general. Manufacturers of raw materials, such as pigments, fillers or fluxes, will be interested in the availability of the service of this company. Many smaller rubber companies, and especially those just starting in the rubber business, will likewise welcome the prospect of obtaining expert advice without increase of overhead costs.

THE SETHMOUR CHEMICAL CO., Mount Morris, N. Y., at its recent annual meeting elected Howard I. Averill president. Other officers elected were: O. B. Dow, vice-president; W. T. Larkin, secretary and treasurer; and L. C. Donovan, foreman.

THE AMERICAN VITRIFIED CHINA MANUFACTURERS, East Liverpool, O., at its recent annual meeting elected the following officers for the ensuing year: President, C. E. Jackson, head of the Warwick China Co., Wheeling, W. Va.; vice-president, D. William Scammell, Maddock Pottery Co., Trenton, N. J.; secretary and treasurer, Arthur E. Mayer, head of the Mayer China Co., Beaver Falls, Pa.

THE DU PONT CO., of Wilmington, Del., at its recent stockholders meeting elected the following directors: H. F. Brown, H. E. Lackey, J. W. Elms, F. B. Davis, Jr., Hunter Grubb, W. F. Rascoe, Fin Sparre and Clifford McIntyre.

THE STANDARD BRICK & TILE CO., Portland, Ore., has elected A. H. Wethey, Jr., president. Otis J. Fitch has been appointed sales manager for the company.

R. E. Clarke, formerly vice-president of the Seaboard Oil Co., New York, and F. W. Steadman, previously connected with the Carson Petroleum Co., have organized a new company under the name of **CLARKE & STEADMAN**, to engage in the oil business. Offices have been established in the Produce Exchange Bldg.

THE NICKLE ENGINEERING WORKS, Saginaw, Mich., manufacturer of agitator equipment for chemical tanks, has leased a portion of the Schemm Brewing Co. plant, 920 North Hamilton St., for machine shop purposes.

THE AMERICAN CROSBOTING CO., Louisville, Ky., is erecting a new plant for timber preserving at New Haven, Conn. This plant consists of a retort house with two cylinders 7 ft. in diameter and 150 ft. long, with the necessary pumping machinery and other required equipment. The boiler house will be a modern type of 600-horsepower. In addition there will be large tie handling facilities. Contract arrangements have been entered into for the building of the plant and construction is now under way. The plant will be the last word in engineering design for tie treating. The product will be used chiefly by the New York, New Haven & Hartford R.R.

THE UNIFORM ADHESIVE CO., Brooklyn, N. Y., is now operating its new plant at Bush Terminal, producing glues, gums, pastes and adhesives. Dr. Jerome Alexander is president and Walter Alexander, vice-president.

THE QUIOLEY FURNACE SPECIALTIES CO., New York City, announces that it will be represented in the Chicago territory by H. M. Thompson, who was formerly identified with the Thomas Moulding Brick Co., who succeeds Bell & Gossett, former agents. Mr. Thompson will make his headquarters at 105 West Monroe Street, Chicago. It is also announced that the Federal Supply Co., East 79th Street, Cleveland, O., have been appointed representatives in that territory.

THE GREEN ENGINEERING CO., East Chicago, Ind., announces the opening of a direct branch sales office in suit 941, Monadnock Bldg., Chicago, Ill. The former agency representation has been discontinued in the

Chicago district. J. W. Himmelsbach has been appointed district manager. P. Albert Poppenhusen, president of the company, will maintain an office at the Chicago address, while the general sales office will remain at the factory.

THE WILSON WELDER & METALS CO. announces the removal of its general offices and Bush Terminal factory to 132 King St., New York City. This company announces that the change has increased its facilities for service in certified plastic arc-welding metals by the installation of improved equipment.

THE CUTLER-HAMMER MFG. CO. has moved its Boston office from the Columbian Life Bldg. to Rooms 403 and 404, Harvey Bldg., Chancery St. C. W. Yerger is manager.

THE COMBUSTION ENGINEERING CORP. has opened a new branch office at 806 First National Bank Bldg., Pittsburgh, Pa., which will be in charge of W. C. Stripes, formerly manager of the Philadelphia office.

H. L. DICK, Chicago manager for Emil E. Lungwitz, has returned to Chicago after a six months' stay at the New York office of the company.

WESTINGHOUSE, CHURCH, KERR & CO.'S employees, to the number of 140, recently organized the "W. C. K. Association." The object of this organization is the maintenance of the friendship formed by its members during their years of service with Westinghouse, Church, Kerr & Co. The association meets every Wednesday for lunch between 12 and 1 o'clock at Zimmermann's restaurant, 103 Fulton St., New York City. The secretary, A. H. Tummel, 131 Warwick St., Brooklyn, N. Y., will be glad to hear from former employees who desire to join the association.

THE EXETER MACHINE WORKS, INC., West Pittston, Pa., has appointed J. E. Holveck district sales representative in the Pittsburgh district. Mr. Holveck was until recently connected with Crawford & Cameron of Pittsburgh, and was formerly designing engineer for the Aldrich Pump Co. of Allentown, Pa. This company also announces the appointment of the Allen Engineering Co. as sales agent for the Exeter rotary pump line in the Boston district.

THE ENGINEERING ADVERTISERS' ASSOCIATION of Chicago is now publishing a monthly bulletin in the interest of its members, giving a digest of the speeches made at the various meetings and other information and facts regarding the movement of goods from industry to industry, personal notes, etc. A limited number of extra copies of the "Bulletin" will be sent upon request to the advertising manager of concerns selling technical or engineering products.

THE MAHER ENGINEERING CO., Chicago, announces that C. B. Adams has been appointed vice-president and sales manager and C. H. Peterson has been appointed secretary-treasurer and general manager.

ALFRED M. BEST CO., insurance and advisory service, New York, announces the appointment of E. H. Seaman to take charge of its advisory and engineering departments. Mr. Seaman will direct all operations in the Eastern and Southern fields and will devote special attention to industrial plants with a view to reducing industrial waste and cost of insurance. He has specialized in fire protection and prevention for over 15 years in the United States and Canada.

The executors of the estate of **JOHN C. WIARDA** have sold the assets of the chemical manufacturing and jobbing business at 273 Green St., Brooklyn, N. Y., to Howard B. Bishop of 101 Park Ave., New York. Mr. Bishop is a chemical engineer and was for many years connected with the General Chemical Co. and the National Aniline & Chemical Co. The new management will continue the business under the name of John C. Wiarda & Co., Inc., and will enlarge and extend its manufacturing and jobbing facilities.

THE PITTSBURGH ELECTRIC FURNACE CORP., Pittsburgh, Pa., announces that A. D. Keene, formerly electric furnace engineer of the General Electric Co., Schenectady, N. Y., is now connected with it as engineer on electric furnace designs and applications in the steel and metal industries. Mr. Keene has moved his residence from Schenectady to Pittsburgh, Pa.

THE UNITED CHEMICAL & ORGANIC PRODUCTS CO., formerly at 217 Broadway, have moved to larger quarters at 401 East 45th St., New York City.

THE WHITING CORP., Harvey, Ill., has purchased a controlling interest in the Grindle Fuel Equipment Co., manufacturer of complete powdered coal plants for use in connection with malleable furnaces, annealing ovens, steam boilers, billet heating and various other types of furnaces. The Grindle Fuel Equipment Co. has moved its offices to Harvey, Ill., and will continue its business under the same name; the

Whiting Corp. will manufacture all Grindle equipment. The following officers have been elected: President, B. H. Whiting; secretary and treasurer, T. S. Hammond; vice-president and general manager, A. J. Grindle. The members of the board of directors are as follows: J. H. Whiting, B. H. Whiting, A. J. Grindle, R. H. Bourne, N. S. Lawrence and A. H. McDougall.

JOHN T. HARRIS, of the Chicago office of the Albright-Nell Co., transferred his activities to 829 New York Life Bldg., Kansas City, Mo., where he will act as Southwestern representative of the company.

LIPPINCOTT, MILL & CO., INC., has been granted a New York charter to deal in coal, coke, ores, scrap, iron and steel products and ferro-alloys, and to do a general importing and exporting business. The new company has offices at 17 Battery Pl., New York, and in the Hippodrome Bldg., Cleveland. G. W. Lippincott, head of Lippincott & Co., wholesale coal dealers, Hippodrome Bldg., Cleveland, is president. William H. Mills, New York, who retired 3 years ago as president of Naylor & Co. after a connection of 33 years with that interest, is vice-president and treasurer. A. L. Irwin, of Lippincott & Co., Cleveland, is vice-president. P. L. Smith, New York, for 19 years identified with Naylor & Co., resigned as assistant to the president and director of that company to become secretary of Lippincott, Mills & Co., Inc.

THE PEERLESS WIRE FENCE CO., with headquarters at Adrian, Mich., has acquired property at Memphis, Tenn., for the installation of a wire fence-manufacturing plant. Eleven weaving machines have been installed to date, and a shipment of 250 tons of wire is en route to the plant. This capacity will be doubled within the year. P. E. Underhill will have charge of the new plant, which is located at 1051 Florida Street.

ORTON & STEINBRENNER CO. of Chicago, manufacturer of locomotive cranes, clam and orange-peel buckets, has appointed the F. E. Richmond Machinery Co., 117 West Second St., Salt Lake City, Utah, as its Western agent.

Coming Meetings and Events

AMERICAN CERAMIC SOCIETY will hold its twenty-fourth annual meeting at St. Louis, Feb. 27 to March 3, 1922.

AMERICAN CHEMICAL SOCIETY will hold its spring meeting at Birmingham, Ala., April 4 to 7, 1922.

AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Baltimore, April 27, 28 and 29, 1922.

AMERICAN FOUNDRYMEN'S ASSOCIATION will hold its next convention and exhibit at Cleveland, O., during the week of April 24, 1922. Meetings will be held in the spring instead of in the fall as heretofore.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its spring meeting in New York the week of Feb. 20, 1922.

AMERICAN WOOD PRESERVERS ASSOCIATION will hold its annual meeting Jan. 24, 25 and 26 at the Hotel Sherman, Chicago, Ill.

NEW JERSEY CHEMICAL SOCIETY holds a meeting at Stettens Restaurant, 842 Broad St., Newark, N. J., the second Monday of every month.

PERKIN MEDAL will be presented to William M. Burton by the Society of Chemical Industry at its meeting Jan. 13 at the Chemists' Club, New York.

STAMFORD CHEMICAL SOCIETY, Stamford, Conn., holds a meeting in the lecture room of the local high school on the fourth Monday of each month, except June, July, August and September.

The following meetings are scheduled to be held in Rumford Hall, the Chemists' Club, New York: Jan. 13—Society of Chemical Industry, Perkin Medal; Feb. 10—American Electrochemical Society (in charge), Society of Chemical Industry, Société de Chimie Industrielle, American Chemical Society, joint meeting; March 10—American Chemical Society, Nichols Medal; March 24—Society of Chemical Industry, regular meeting; April 21—Society of Chemical Industry (in charge), American Electrochemical Society, Société de Chimie Industrielle, American Chemical Society, joint meeting; May 5—American Chemical Society, regular meeting; May 12—Société de Chimie Industrielle (in charge), American Chemical Society, Society of Chemical Industry, American Electrochemical Society, joint meeting; May 19—Society of Chemical Industry, regular meeting; June 9—American Chemical Society, regular meeting.